Agenda Item D.1
Situation Summary
June 2014

LOWER COLUMBIA RIVER NATURAL COHO HARVEST MATRIX UPDATE

Lower Columbia natural (LCN) coho stocks in the Lower Columbia River evolutionarily significant unit (ESU) were listed as threatened under the Endangered Species Act (ESA) in 2005 and efforts to recover these populations often have a constraining effect on ocean and inriver salmon fisheries. Additionally, stocks on the Oregon side of the river have been listed under the Oregon ESA since 1999. Current and Federal ESA implementation has relied on a matrix approach that considers parental spawner escapement and marine survival as a harvest control rule to determine allowable fishery impacts. However, the states of Oregon and Washington have questioned the original scientific and policy basis of the current matrix, and new information is available regarding the status of the populations since development of the current matrix control rule; thus, the Council has scheduled a review and possible revision of the matrix in current use.

At its April 2014 meeting, the Council heard a report from the newly-formed *ad hoc* Lower Columbia Natural Coho Workgroup (LRC Workgroup) and provided guidance on the process and schedule for the development of alternative control rules. The Council directed the LRC Workgroup to develop recommendations on the status of Lower Columbia River coho populations, alternative harvest policies, risk assessment methods and criteria, and to draft a report on coho populations in the Willamette River above Willamette Falls. Since releases of hatchery fish from the LCN ESU ended just above Willamette Falls in 1996, a significant population of natural spawning fish has blossomed on the edge of this ESU. The LRC Workgroup was asked to investigate genetic and population strength information on this group of fish for possible inclusion in a separate matrix from the one that just includes populations within the currently designated ESU.

The LRC Workgroup met at the Council office in Portland, Oregon on May 15 to discuss recommendations and complete two reports to the Council, an overall progress report (Agenda Item D.1.a, Attachment 1) and a report on Willamette River coho (Agenda Item D.1.a, Attachment 2). A webinar meeting of the Salmon Technical Team and Salmon Advisory Subpanel (SAS) will occur on June 12 to consider preparing a statement for the agenda item at the June Council meeting.

LRC Workgroup Vice-Chair, Mr. Jeromy Jording, will present the reports to the Council at the June meeting. The Council is tasked with considering the recommendations of the LRC Workgroup and providing guidance on further development of alternative harvest matrices and the associated risk analysis. The LRC Workgroup is planning to convene two meetings between the June and September Council meetings to finalize a range of alternatives. The LRC Workgroup is also interested in convening a joint meeting with the Salmon Advisory Subpanel in advance of the September Council meeting. At the September Council meeting in Spokane, Washington, the Council is scheduled to adopt a range of alternatives for public review before identifying a preferred alternative at the November Council meeting in Costa Mesa, California.

Council Task:

Provide guidance on the next steps in the development of alternative harvest control rules.

Reference Materials:

1. Agenda Item D.1.a, Attachment 1: LRC Workgroup Progress Report.
2. Agenda Item D.1.a, Attachment 2: Willamette River Coho and the Lower Columbia River Coho ESU Boundary Report.

Agenda Order:

a. Agenda Item Overview — Mike Burner
b. Reports and Comments of Advisory Bodies and Management Entities
c. Public Comment
d. Council Discussion and Guidance as Appropriate

PFMC
05/30/14

LRC WORKGROUP – PROGRESS REPORT

This is a progress report on results of the May 15, 2014 work session of the *Ad Hoc* Lower Columbia River Natural Coho (LRC) Work Group. This group was established to explore existing and alternative harvest policies for Columbia River coho. The May work session focused on a review of the available information and development of an approach for identifying and evaluating alternative harvest control rules. Specifically, the Group reviewed the status of Lower Columbia Natural coho populations, the current harvest control rule matrix, and the risk analysis of LCN harvest policy completed in 2013. Based on this review, the Work Group identified the following approach for their effort.

1. Explore the potential for streamlining the harvest control-rule matrix structure.

The current harvest control rule is based on a matrix approach that determines allowable fishery impacts based on parental spawner escapement and marine survival. This matrix is complex, including specific harvest rates for 20 combinations of five escapement and four survival index categories. This complexity makes it difficult for managers and fishers to understand and evaluate the implications of different alternatives. The Work Group examined the technical basis of the general matrix strategy and the specific definition of categories. Based on this examination, it was concluded that the current matrix complexity may not be necessary or entirely effective.

Harvest rates are the same for many matrix cells and several categories and cells seldom or never occur. For data-rich populations, natural coho abundance and recruits per spawner was strongly correlated with a marine survival index based on hatchery jacks/smolt, so there is a justifiable rationale for a related abundance-based harvest strategy. However, abundance was weakly related to parental escapement which calls into question the definition of five parental escapement categories, particularly since natural coho escapement is also measured with substantial error in most populations.

The workgroup identified a number of alternative matrix structures for consideration including 1x3, 1x5, 2x3, and 3x3 frameworks. Risk/benefit assessments of potential alternative structures will be conducted prior to the July Work Group meeting in order to develop specific recommendations.

2. The work group will assess conservation risks of the fishery strategy based on effects on primary populations, representative of all three spatial strata of the Evolutionary Significant Unit (ESU).

An essential objective of the fishing strategy for LCN coho is to avoid jeopardizing long term viability or precluding recovery of LCN coho, including primary populations of all three spatial strata (Coast, Cascade, and Gorge). Salmon recovery plans adopted by Washington, Oregon, and NMFS, identify recovery objectives for LCN coho that designate a subset of all populations as primary targets for restoration to high levels of viability based on abundance, productivity spatial structure and diversity. A total of 16 of the 24 lower Columbia populations were identified in recovery plans as primary populations. The remainder were identified as contributing populations where recovery measures are expected to result in some improvement, or as stabilizing populations where measures are expected to prevent further declines. Of the primary populations, at least three were identified in each of the three spatial strata within the ESU. Primary populations of coho will require some of the most significant improvements in status, hence, will be most constraining to a viable recovery fishing strategy.

Previous application of the coho harvest matrix was based on Sandy and Clackamas coho which are two of the stronger populations in the ESU and the only two for which long-term stock assessment data were available. Over the last five to ten years, data has been collected on the status of additional natural populations.

Risk assessments will incorporate recent data which now provides an empirical basis for assessment of representative populations in addition to the Sandy and Clackamas. Any parental criteria included in future matrices will likely be based on average values of representative populations where significant data is available.

3. Status of Willamette coho might inform our understanding of population dynamics and response to recent fishing patterns but does not change the need to develop effective fishing alternatives for management of coho populations that are in the current ESU.

The Work Group reviewed current information on Willamette coho prepared by ODFW and NMFS. Willamette River tributaries upstream from Willamette Falls currently support naturally-produced coho that have often been the largest return of natural coho in the lower Columbia in recent years. Willamette coho were not included in the listed ESU, primarily because access was historically blocked by Willamette Falls. However, a naturally-producing population has become established following decades of hatchery releases, which were discontinued after 1996. Ladder counts at Willamette Falls provide some of the most accurate information on status of a naturally-producing coho population in the region.

The appropriate status of Willamette coho relative to the listed ESU and coho recovery goals has been debated by some. On the one hand, this population is not part of the ESU because it has colonized streams where it is not native. On the other hand, it appears to be a viable naturally-producing population which is the goal for the ESU.

NMFS's West Coast Region and Northwest and Southwest Fisheries Science Centers are still assessing the scope of the status review and are considering taking up boundary questions related to Columbia River coho as part of the next formal 5-year status review scheduled for 2016. **NMFS advises that their ESA analysis will be on the current ESU. Willamette coho is not part of the ESU. Therefore, NMFS will not use Willamette information in writing the Biological Opinion.**

The Work Group will proceed with the understanding that any fishery strategy must effectively protect listed coho populations throughout the designated ESU. The risk assessment will include Willamette coho to inform expectations for the response of a relatively strong coho population under various fishing scenarios. The degree to which the Willamette population might be considered representative of other coho populations in the ESU is unknown.

4. Evaluate effects of fishing strategies on coho conservation risk utilizing the assessment and model adapted by ODFW and WDFW in 2013.

A harvest strategy risk assessment was prepared by ODFW and WDFW for LCN coho using an adaptation of the Lower Columbia River tule fall Chinook risk model. This model analyzes effects of fishing on natural population status using a stochastic stock-recruitment model in a Population Viability Analysis framework like that employed in salmon ESA status assessments and recovery plans. The 2013 LCN assessment was vetted in a 2013 salmon methodology review (November 2013 Briefing Book, Agenda Item C.2.s, Attachment 2, available on the Council web site). At the November 2013 Council session, the Scientific and Statistical Committee suggested improvements and found the risk analysis to be "sound" and "suitable for ranking the relative risk of various harvest scenarios."

The Work Group will incorporate results of the 2013 risk assessment into their effort and also complete additional analyses with the same modeling approach. Model sensitivity analysis will be used to evaluate the effects of alternative matrix structures and different combinations of fishing rates.

5. Analyses of alternative fishing strategies will consider both conservation risks and fishery effects.

Previous quantitative risk assessments for coho and Chinook have demonstrated that many different combinations can produce equivalent conservation risks. For instance, the current coho matrix produces population risk levels equivalent to a fixed 15-16% harvest rate. However, abundance-based management defined by a matrix approach can provide significant fishery benefits by allowing increased opportunity during large return years when risks of low escapement are negligible. The 2013 coho harvest strategy risk assessment primarily focused on conservation risks and did not attempt to estimate fishery benefits. The Work Group will include assessments of fishery effects in the current analysis in order to provide a basis for weighing tradeoffs between conservation risks and harvest benefits.

Fishery effects of alternative fishing strategies will be evaluated based on the implications of different fishing rates to fishery configurations and the likely frequency of occurrence of each. For instance, fishing rates can be identified in the ocean or Columbia River fisheries corresponding to no coho target fisheries, full coho retention fisheries, and maximum potential rates given other constraints.

6. The work group will examine the technical feasibility of evaluating risk tradeoffs between fishing effects on spawning escapements and the incidence of hatchery-origin strays in natural production areas.

Hatchery-origin coho dominate the Columbia River return and these fish are primarily produced for fishery mitigation purposes. Consequently, it is difficult to separate fishery and hatchery effects in considerations of natural coho population status. As a result, recovery plans adopted by Washington, Oregon and NMFS include a series of closely-related and complementary fishery and hatchery measures.

Conservation risks of fishery alternatives are being evaluated based on the frequency of critical low natural spawning escapements which potentially reduce long-term population viability. Higher fishing rates can increase risk by increasing the likelihood of small escapements. Higher fishing rates might also reduce risk by removing larger numbers of hatchery fish which impact natural population productivity. Higher productivity will increase long-term viability as populations are less likely to fall to critical low levels and more likely to rebound quickly. The 2013 coho risk assessment discussed this relationship but did not incorporate changes to productivity that might accrue from reduced hatchery spawning.

The impact of hatchery-origin spawners on wild productivity is uncertain and subject to considerable debate. However, the *Hatchery Scientific Review Group* (HSRG) has developed tools for evaluating hatchery spawner impacts on natural population productivity based on a number of assumptions. These relationships were used in a comprehensive hatchery review for the Columbia Basin by the HSRG, and were included as a component of the Washington recovery plan. These efforts led to the implementation of a series of hatchery reforms, which, for coho, included elimination of some programs, program changes, establishment of wild fish refuges, and increased stock assessment.

The Work Group will explore the feasibility of including fishery-hatchery interaction effects in assessing conservation risks based on tools developed by the HSRG. Percentages of hatchery-origin natural spawners will also be documented by population where available. Results will be evaluated to determine if appropriate for consideration quantitatively or qualitatively in the risk analysis.

7. An appropriate risk standard for evaluating alternative fishing strategies remains to be determined.

As noted by the SSC, the assessment methodology provides a robust means of identifying relative risks of fishery alternatives to natural coho populations but absolute risk levels calculated by this method are much more subjective. Risk levels associated with current fisheries might be regarded as a benchmark against which other alternatives can be measured. However, current fishing levels were themselves based on subjective considerations.

Current fishing levels were effectively established in 2006 and 2007 when NMFS implemented further reductions under federal rules relative to those in place since 2001 under state rules. Rates were previously indexed to Sandy and Clackamas coho seeding levels in part because data on other coho populations was quite limited. However, Sandy and Clackamas may not be representative of many of the weaker populations in the ESU. Therefore, reduced fishing rates were implemented as a precautionary measure for protecting significant coho populations throughout the ESU.

Since the federal listing of coho in 2005, substantial new information on the status of natural coho populations has been collected by ODFW and WDFW. This data now provides a means of conducting a formal risk assessment to demonstrate the likely effects of proposed harvest strategies as identified by NMFS in a 2011 guidance letter.

Results of the 2013 risk assessment conducted by ODFW and WDFW suggest that it will be difficult to significantly reduce already-low fishery-related risk levels and that further risk reductions would have drastic fishery repercussions. Unlike tule Fall Chinook, current low fishing levels for LCN coho may not provide room for a "win-win" strategy where both reduced risk and increased flexibility can be achieved. The win-win solution was possible for Fall Chinook where fishing rates because substantially greater and within an effective range.

The Work Group anticipates that a number of alternative fishery strategies might increase fishery opportunities with no or little effective increase in wild population risk. A key consideration will be whether marginal increases in model-derived risks relative to the current level are significant in the broader context of current coho information and status.

8. Future Workload and Meeting Schedule.

The Workgroup's next formal meeting will be July 16th at the Council offices in Portland and will focus on reviewing Council guidance from the June Council meeting, discussion of preliminary model results, and developing a range of alternative harvest matrices for further analysis. The Workgroup then plans to develop a report for the September Council meeting via email and phone until they meet again on August 14th to finalize a range of analyzed alternatives and a set of recommendations for Council review.

The Council is tentatively scheduled to receive an update at the June Council meeting, adopt alternatives for public review at the September Council meeting, and adopt a preferred alternative at the November Council meeting.

The Workgroup stressed the importance of keeping the Salmon Advisory Subpanel (SAS) informed of progress and developments. SAS members are encouraged to attend Workgroup meetings. The Workgroup strongly recommended a joint session of the Workgroup and the SAS at or just before the September Council meeting in Spokane, Washington. A meeting in Portland in advance of the June Council meeting may be more convenient and cost effective than meeting in Spokane.

Willamette River Coho and the Lower Columbia River Coho ESU Boundary Report

The newly appointed Lower Columbia Natural Coho Workgroup (LRC Workgroup) met for the first time at the April 4, 2014 Pacific Fishery Management Council meeting. The LRC Workgroup discussed the process to follow, schedule for future meetings, and assignments. Members from NOAA's National Marine Fisheries Service (NMFS) and the Oregon Department of Fish & Wildlife (ODFW) agreed to take the lead on development of a Fact Sheet to provide information relative to coho populations above Willamette Falls and the existing Evolutionarily Significant Unit (ESU) boundary. NMFS was tasked with describing status, background and determination criteria for the existing boundary of the lower Columbia River (LCR) natural coho salmon ESU; ODFW was tasked with summarizing existing information regarding historical upstream passage and releases of hatchery coho salmon in areas above Willamette Falls. This report is intended to complete the assignment as we understood it.

In 2004 the Population Identification Subcommittee of the Willamette-Lower Columbia Technical Recovery Team (WLC-TRT) convened in response to the proposed listing of LCR natural coho under the U.S. Endangered Species Act (ESA). The Subcommittee determined 24 historical demographically independent populations (DIPs) of listed coho salmon (*Onchorhynchus kistuch*) in the LCR coho salmon ESU, with no coho salmon DIPs in the upper Willamette River (Myers et al. 2006). The authors relied on a number of types of information to identify historical populations. In general, there were six different types of information utilized:

1) geography,
2) migration fidelity,
3) genetic attributes,
4) life history patterns and morphological characteristics,
5) population dynamics, and
6) environmental and habitat characteristics.

Genetic analysis of coho salmon populations provided limited information about population distinctiveness. This was thought to be due in large part to the extensive programs of hatchery releases and interbasin transfers between hatcheries, in tandem with the small number of naturally produced fish. Therefore the boundaries for historical DIPs were in part established using information related to two isolating mechanisms: homing fidelity and migration timing. Homing fidelity was examined to estimate the extent of adult exchange among spawning populations, whereas adult run timing often is coordinated with stream hydrology. The WLC-TRT generally believed that the homing fidelity of coho salmon was more similar to steelhead than to Chinook salmon or chum salmon.

The environmental and habitat characteristics of Willamette Falls were determined to provide the isolating mechanism for it to serve as an ESU boundary and likely barrier for fall-migrating salmonids such as coho. This is consistent with the WLC-TRT separating the LCR Chinook salmon ESU from the Upper Willamette River Chinook salmon ESU and the LCR steelhead Distinct Population Segment (DPS) separated from the Upper Willamette River steelhead DPS.

The WLC-TRT noted a number of contemporary references documenting the presence of coho salmon in tributaries to the Willamette River above Willamette Falls. The first recorded observations of naturally occurring coho salmon in all cases followed either opening access to the area via construction of the fish ladder at Willamette Falls in 1882 or the introduction of LCR coho salmon by ODFW into those subbasins[1] (Table 1). The WLC-TRT reported old-time residents claiming that silver salmon were not present in these streams prior to about 1920, and that Dimick and Merryfield (1945) asserted that coho salmon above Willamette Falls were an "artificial establishment from hatchery-reared fish." These findings lead the WLC-TRT to determine that coho salmon historically would not have ascended Willamette Falls before it was laddered. According to passage records from ODFW dating back to 1966, coho have been observed utilizing the Willamette Falls fish ladder annually (Table 2). Observations of fin-marked adult coho passing the Falls show that hatchery-origin fish continue to make their way into the upper basin (Table 3).

The most current NMFS LCR natural coho salmon ESU status review (Ford 2011) discussed the transitional zone between the gorge boundary and the interior Columbia River region. The WLC-TRT's LCR coho salmon ESU boundary designation, is based largely on extrapolation from information about the boundaries for Chinook salmon and steelhead, with Ford (2011) suggesting it would be reasonable to assign the Klickitat population to the LCR coho salmon ESU. This would thereby establish the use of Celilo Falls (The Dalles Dam) as a common boundary for LCR ESUs and DPSs. No other boundary modifications have been considered since the original boundary designations were determined.

The NMFS's next status review is scheduled to be completed by 2016. NMFS's West Coast Region and Northwest and Southwest Fisheries Science Centers are currently discussing the scope of the next status review. Boundary delineation questions concerning the Willamette Falls and Celilo Falls for the LCR coho salmon ESU have been queued for consideration, but they will not be resolved until then. Therefore NMFS will continue to use the current WLC-TRT designated LCR coho salmon ESU populations when considering the status of the ESU, which does not include coho above Willamette Falls or within the Klickitat River basin.

References:

Dimick, R. E., and F. Merryfield. 1945. The Fishes of the Willamette River System in Relation to Pollution. Oregon State College, Engineering Experiment Station, Corvallis.

Ford, M. J., editor. 2011. Status Review Update for Pacific salmon and steelhead listed under the Endangered Species Act: Pacific Northwest. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-113. 281p.

Myers, J. M., C. Busack, D. Rawding, A. R. Marshall, D. J. Teel, D. M. V. Doornik, and M. T. Maher. 2006. Historical population structure of Pacific Salmonids in the Willamette River and Lower Columbia River Basins. U.S. Dept. of Commerce, NOAA Tech. Memo., NMFS-NWFSC-73, 311p.

[1] The majority of hatchery fish released into areas above Willamette Falls were sourced from LCR hatcheries. The releases were comprised primarily of fry, sub-yearlings, yearlings, or smolts; however, some adults were also introduced. The vast majority appear to be LCR early stock. There were instances of Oregon coastal stocks released during the late 1950s (two years), the late 1960s (five years), and early 1970s (two years) but these fish made up a relatively small proportion of the releases during those years.

Table 1. Hatchery coho salmon releases into areas above Willamette Falls, Brood Years 1951–1996.

Brood Year	Fry	Fed Fry	Fingerling	Yearling	Pre-smolt	Smolt	Total
1951			500,000				500,000
1952				10,000			10,000
1953			275,000				275,000
1954			56,000	50,486			106,486
1955			80,000	104,877			184,877
1956	24,549		529,862				554,411
1957			722,196	90,316			812,512
1958			344,696				344,696
1959			277,199	91,784			368,983
1960			100,913	105,717			206,630
1961	1,572,068			138,318			1,710,386
1962	5,359,996			61,814			5,421,810
1963				178,571			178,571
1964	6,886,100		816,360	296,224			7,998,684
1965	9,727,546						9,727,546
1966	9,777,986		886,105				10,664,091
1967	6,511,935						6,511,935
1968	5,700,471		249,490	1,154,129			7,104,090
1969	6,613,306		78,020	1,375,798			8,067,124
1970	883,235			1,236,601			2,119,836
1971	1,364,132			1,253,855			2,617,987
1972	1,601,177		469,172	1,270,174			3,340,523
1973	258,366		373,000	189,746			821,112
1974	448,963		330,301	607,522			1,386,786
1975				410,553			410,553
1976	635,742			169,836			805,578
1977				164,983			164,983
1978				60,102			60,102
1979				59,892			59,892
1980	370,560			54,943			425,503
1981						182,000	182,000
1982					2,917,000	60,000	2,977,000
1983					648,000	250,000	898,000
1984					3,891,500		3,891,500
1985					188,000	60,000	248,000
1986					501,000	167,000	668,000
1987						60,000	60,000
1988						60,000	60,000
1989						60,229	60,229
1990						59,913	59,913
1991						60,052	60,052
1992						60,239	60,239
1993						59,250	59,250
1994		15,102				59,919	75,021
1995		7,969				60,000	67,969
1996						60,152	60,152
Totals	57,736,132	23,071	6,088,314	9,136,241	8,145,500	1,318,754	82,448,012

(Information for years 1951-80 from: *Williams, R. 1983. Releases of Coho Salmon into the Upper Willamette River, Oregon. Information Report Number 83-3*; for years 1981-88 from: *Kostow, K. 1991. Columiba [sic] Basin Coho, Complied [sic] as comments to NMFS Endangered Species Act Record*; and for years 1989-96 from: *RMPC Data Run 04-29-2014*)

Table 2. Escapement of coho salmon over Willamette falls, 1966–2013. (ODFW 2014)

Year	Adults	Jacks	Total
1966-69 Average Range	6,800 3,300 – 12,000	5,100 1,600 – 14,000	11,900 6,300 – 17,700
1970-74 Average Range	10,400 1,500 – 17,900	7,800 1,600 – 19,500	18,200 5,400 – 37,400
1975	5,922	6,927	12,849
1976	2,333	2,217	4,550
1977	1,007	2,120	3,127
1978	1,711	3,891	5,602
1979	1,788	1,691	3,479
1980	1,276	1,365	2,641
1981	1,032	2,417	3,449
1982	1,702	3,517	5,219
1983	949	2,840	3,789
1984	2,735	2,560	5,295
1985	2,788	2,278	5,066
1986	2,930	2,240	5,170
1987	1,589	3,224	4,813
1988	3,707	4,985	8,692
1989	1,946	1,741	3,687
1990	901	1,817	2,718
1991	921	815	1,736
1992	940	588	1,528
1993	427	236	663
1994	685	174	859
1995	582	600	1,182
1996	315	976	1,291
1997	1,407	428	1,835
1998	373	386	759
1999	635	623	1,258
2000	2,839	773	3,612
2001	1,736	402	2,138
2002	2,337	2,417	4,754
2003	7,908	1,869	9,777
2004	2,849	524	3,373
2005	1,322	271	1,593
2006	6,186	1,614	7,800
2007	6,678	924	7,602
2008	4,048	2,971	7,019
2009	25,298	2,094	27,392
2010	20,103	1,988	22,091
2011	3,393	1,969	5,362
2012	6,573	6,370	12,943
2013	18,627	4,111	22,738

Table 3. Fin-mark status of adult coho observed passing Willamette Falls, 2007–2013. (ODFW 2014)

Year	Fin-marked	Unmarked	Total
2007	588	6,092	6,680
2008	462	3,586	4,048
2009	664	24,625	25,298
2010	409	19,691	20,100
2011	128	3,264	3,393
2012	36	6,535	6,571
2013	361	18,261	18,622

PFMC
05/22/14

Agenda Item D.1.b
Supplemental NOAA PowerPoint
June 2014

NOAA FISHERIES
West Coast Region

Lower Columbia River Natural Coho Harvest Matrix Update

Ad Hoc Lower Columbia River Natural Coho Work Group

Jeromy Jording

NOAA FISHERIES
West Coast Region

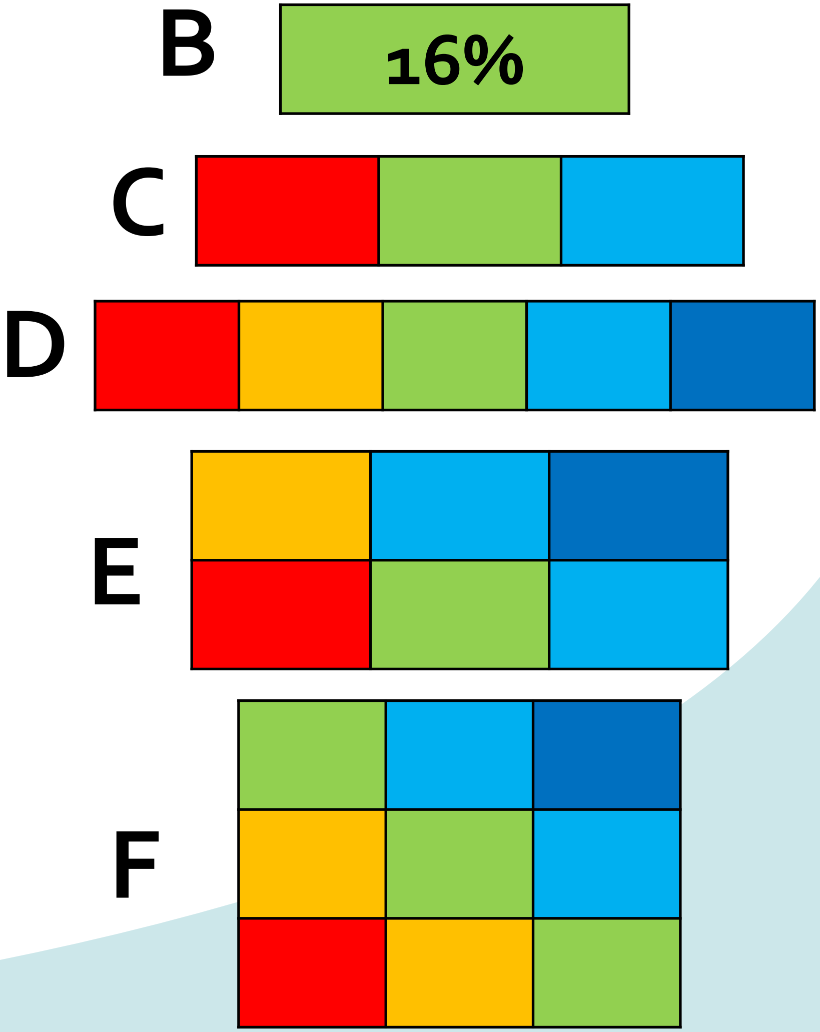
LCN Harvest Control Rule

Parental Escapement (% of full seeding)		Marine Survival Index (based on return of jacks per hatchery smolt)			
		Critical (<.08%)	Low (<.15%	Medium (<.40%)	High (>.40%)
High	>0.75	<8%	<15%	<30%	<45%
Medium	0.75 to 0.50	<8%	<15%	<20%	<38%
Low	0.50 to 0.20	<8%	<15%	<15%	<25%
Very Low	0.20 to 0.10	<8%	<11%	<11%	<11%
Critical	<0.10	0-8%	0-8%	0-8%	0-8%

1. Explore the potential for streamlining

A

<8%	<15%	<30%	<45%
<8%	<15%	<20%	<38%
<8%	<15%	<15%	<25%
<8%	<11%	<11%	<11%
0-8%	0-8%	0-8%	0-8%

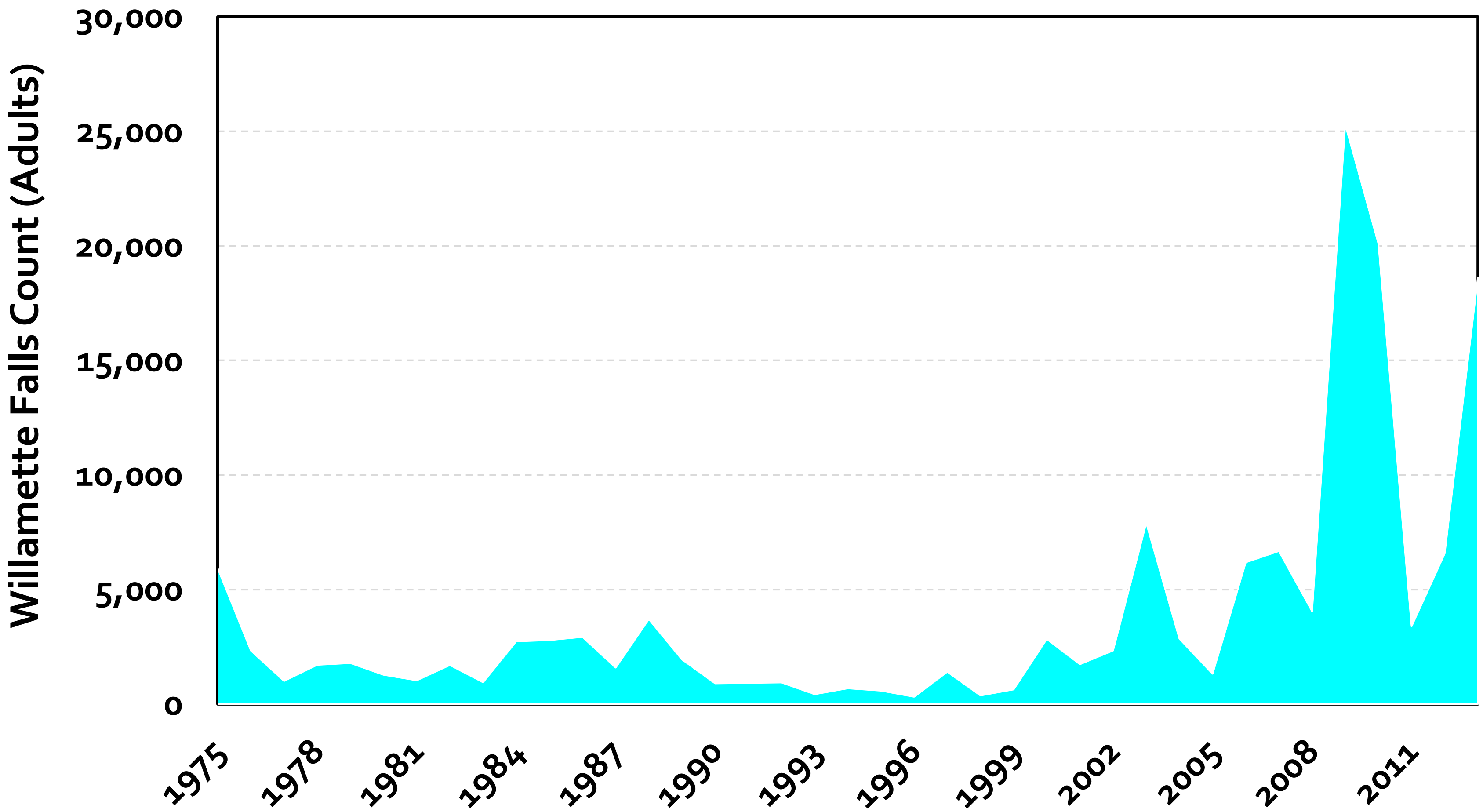


2. Primary populations, three spatial strata

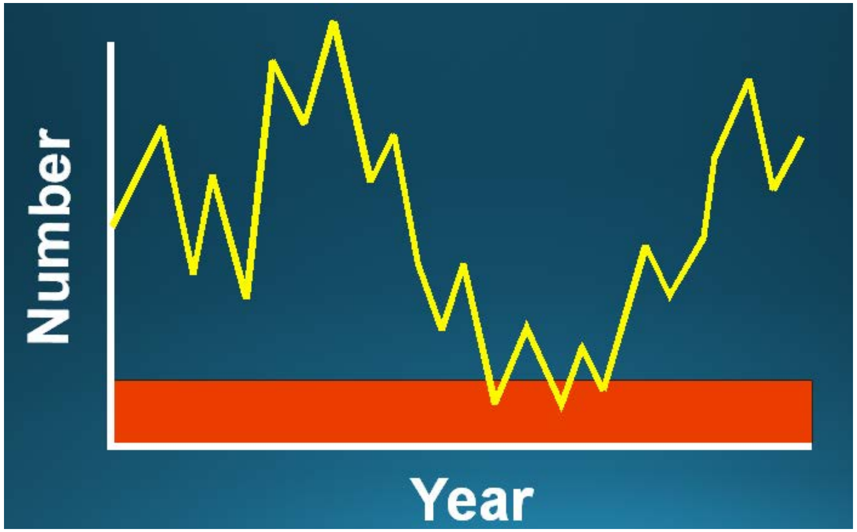
NOAA FISHERIES

Strata	Populations
Coast	**7 Total** (4 Primary)
Cascade	**14 Total** (9 Primary)
Gorge	**3 Total** (3 Primary)

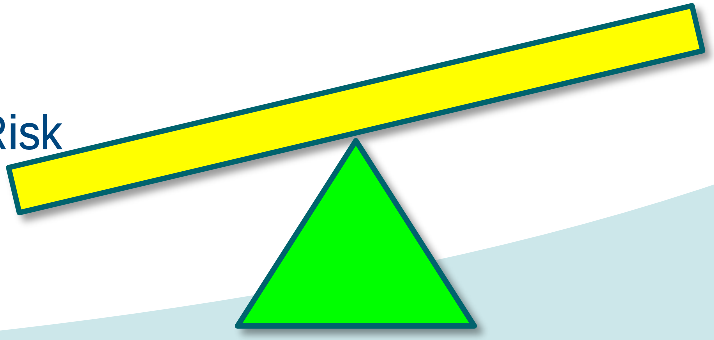
3. Willamette coho salmon



4. Risk assessment framework



5. Conservation vs. fishery tradeoffs



NOAA FISHERIES

West Coast Region

6. Feasibility of including fishery-hatchery interaction effects


Photo by Marilyn & Eric Jordan


image courtesy of Portland District- US Army Corps Of Engineers

7. Risk assessment standard TBD.

Conservation Risk	Fishery Benefit
Win	Win
Win	--
--	Win

8. Schedule

June	Council: Progress Update
July 16	LCN Workgroup Meeting
Aug 14	LCN Workgroup Meeting
Sept.	SAS/Workgroup Session?
Sept.	Council: Alternatives for public review
Nov.	Council: Adopt preferred alternative

Agenda Item D.1.b
Supplemental SAS Report
June 2014

SALMON ADVISORY SUBPANEL REPORT ON LOWER COLUMBIA RIVER NATURAL COHO HARVEST MATRIX UPDATE

The Salmon Advisory Subpanel (SAS) met via webinar with the Salmon Technical Team (STT) and members of the Lower Columbia River Natural Coho Workgroup (LRC Workgroup) on Thursday, June 12, 2014. The SAS reviewed the reports of the LRC Workgroup and received an overview presentation by Mr. Ray Beamesderfer. The SAS appreciates the work that has been done thus far and offers the following comments.

The SAS is supportive of efforts to simplify the management of these stocks including the matrix used to determine appropriate harvest levels. The SAS agrees that the current matrix is overly complex with categories that are seldom or never realized. The SAS intends to work with the LRC Workgroup over the summer in the review and analysis of alternative harvest matrices. The SAS recommends considering matrix alternatives with reduced maximum exploitation rates and slightly less restrictive minimum exploitation rates, but with small increased risk to the stocks.

The SAS is encouraged by recent work by Washington Department of Fish and Wildlife and Oregon Department of Fish and Wildlife to improve our understanding of populations within the current Evolutionary Significant Unit (ESU). The SAS recommends that new information on existing populations be incorporated into the analysis of risk associated with alternative harvest policies. The SAS also believes that these increased monitoring efforts and subsequent improved understanding of the status of Lower Columbia River coho stocks should be a factor in the review of harvest policy.

The SAS reviewed the LRC Workgroup report on coho populations above Willamette Falls (Agenda Item D.1.a, Attachment 2). The SAS is interested in the recent success of these populations and feels they could be informative to our understanding of Lower Columbia River natural (LCN) coho. The SAS recognizes that coho populations above Willamette Falls are not included in the existing ESU and recommends that these populations be considered in the proposed ESU status review by National Marine Fisheries Service (NMFS) in 2015. However, the SAS is not interested in any delay in the development of new harvest policies for this ESU because of future status reviews. The SAS would support the evaluation of a new harvest matrix after three years of implementation. Any revisions to the ESU that may result from the NMFS status review could also be considered at this time.

The SAS appreciates efforts by the LRC Workgroup to work together on the review of the LCN coho harvest matrix. SAS members will attend LRC Workgroup meetings when feasible and requests that LRC Workgroup meetings be streamed online to maximize the potential audience. The SAS supports a joint meeting with the LRC Workgroup in the vicinity of Portland, Oregon in advance of the September 2014 Council meeting and in-lieu of traveling to Spokane. The LRC also recommends a joint meeting with the LRC Workgroup in October to prepare for final Council action on this matter scheduled for the November. Towards that end, the SAS would prefer to be in attendance at the November Council meeting.

PFMC
06/19/14

COLUMBIA RIVER CORMORANT MANAGEMENT PLAN

The U.S. Army Corps of Engineers (ACOE), Portland District is the Federal land manager of East Sand Island, and is currently considering management alternatives to reduce the double-crested cormorant predation on Columbia River basin juvenile salmonids listed under the Endangered Species Act. The management alternatives will be studied in an Environmental Impact Statement (EIS) under the National Environmental Policy Act.

At the April 2013 meeting, Project Manager Ms. Sondra Ruckwardt, provided an informational briefing on the proposed action to the Salmon Advisory Subpanel and indicated that the project was scheduled to provide a draft EIS in the summer of 2013 with a public comment period that would likely span the Council's September meeting in Boise. The draft EIS was not released in 2013 and at the September 2013 Council meeting, the Council directed Council Executive Director Donald McIsaac to send a letter requesting the review be timed to coincide with the Council's April 2014 Council meeting in Vancouver, Washington (Agenda Item D.2.a, Attachment 1).

The ACOE announced plans to release a draft EIS on May 22 with a 45-day public comment period that would encompass the June 2014 Council meeting and this agenda item was scheduled accordingly. However, the draft EIS was not released on May 22 and was not available at the time the June Briefing Book was distributed. The tentative ACOE plan at this time is to release the draft EIS on June 19 with a 45-day comment period. This schedule would require the Council to develop final comments and recommendations at the June 2014 Council meeting with almost no review time. The ACOE reports that the document may be available up to a week earlier than the formal release date of June 19. Council staff will continue to work with the ACOE to maximize Council review time and will send out supplemental materials as soon as they are available.

Additional background material on the project can be found at the following webpage: http://www.nwp.usace.army.mil/Missions/Currentprojects/CormorantEIS.aspx.

Council Action:

Provide Comments to U.S. Army Corps of Engineers.

Reference Materials:

1. Agenda Item D.2.a, Attachment 1: September 30, 2013 letter from Dr. McIsaac to Ms. Ruckwardt regarding the Council request on the content and review of the draft EIS on cormorant predation on juvenile salmonids.
2. Agenda Item D.2.a, Supplemental Attachment 2: Draft Environmental Impact Statement

Agenda Order:

a. Agenda Item Overview — Mike Burner
b. U.S. Army Corps of Engineers Report
c. Reports and Comments of Advisory Bodies and Management Entities
d. Public Comment
e. **Council Action**: Develop Comments on the Cormorant Management Plan for Submission to the U.S. Army Corps of Engineers

PFMC
05/30/14

Pacific Fishery Management Council
7700 NE Ambassador Place, Suite 101, Portland, OR 97220-1384
Phone 503-820-2280 | Toll free 866-806-7204 | Fax 503-820-2299 | www.pcouncil.org
Dorothy M. Lowman, Chair | Donald O. McIsaac, Executive Director

September 30, 2013

Ms. Sondra Ruckwardt, Project Manager
U.S. Army Corps of Engineers, Portland District
P.O. Box 2946
Portland, Oregon 97208

RE: Pacific Fishery Management Council Request Regarding the Content and Review of the Environmental Impact Statement on Double-Crested Cormorant Predation of Juvenile Salmonids in the Columbia River.

Dear Ms. Ruckwardt:

The Pacific Fishery Management Council (Council) met September 12-17, 2013 in Boise, Idaho and reviewed the status of the U.S. Army Corps of Engineers (USACE) Environmental Impact Statement (EIS) on Double-Crested Cormorant Predation of Juvenile Salmonids in the Columbia River. The Council appreciates your presentation to the Salmon Advisory Subpanel at the April 2013 Council meeting in Portland and had anticipated an opportunity to review and comment on the EIS at the September meeting in Boise. The Council continues to be interested in the project and has concerns regarding avian predation of salmonids in the Columbia River. This letter formally requests an opportunity for a thorough Council review when the draft EIS is completed for public comment.

It is the Council's current understanding that the USACE anticipates releasing the EIS for public review and comment in the winter of 2013-2014. The Council is encouraged that the project is moving forward and offers the following recommendations on ways to facilitate Council participation.

The Council's upcoming meeting schedule includes November 1-6, 2013 in Costa Mesa, California, March 8-13, 2013 in Sacramento, California, and April 5-10, 2013 in Vancouver, Washington. The Council recommends that the EIS public comment period coincide with the April 2014 Council meeting because the Council's salmon advisory groups will be in attendance and the meeting location of Vancouver, Washington is a convenient venue for USACE Portland District staff and for many interested Columbia River constituents.

The March 2014 Council meeting would also be an opportunity for Council participation, but its location of Sacramento, California is less advantageous for reasons aforementioned. The agenda for the November 2013 Council meeting is largely set, and the Council does not anticipate that the EIS would be ready with sufficient time for adequate review.

The Council requests that the public review period for the EIS allow adequate time for advanced review before a Council meeting, for deliberation at the meeting, and for drafting of a formal response after the meeting. Specifically, briefing materials for a Council meeting are typically requested three weeks in advance of the start of the meeting and Council staff requests a two-week period following a Council meeting for the documentation and transmittal of Council recommendations.

The Council anticipated the EIS will include a complete accounting and analysis of the effects of cormorant predation on juvenile salmonids and the subsequent adult-equivalent catches in fisheries and adult returns to spawning areas. The Council reviewed the scoping comments summarized in the February 2013 USACE e-newsletter on the topic and looks forward to evaluating the alternatives. The Council would be very appreciative if the appropriate authors and/or principle investigators on the project could be available to meet with Council advisory groups and to attend the Council's session to present the findings and respond to questions.

I understand that this Council requested process would require substantial coordination and participation by the USACE. Please consider that the Council's transparent public process is an ideal forum for soliciting broad and meaningful constituent input. Thank you for your consideration of these recommendations. Should your staff have any questions on this matter, please contact Mr. Mike Burner at the Council office.

Sincerely,

D. O. McIsaac, Ph.D.
Executive Director

MDB:kam

C: Council Members
Mr. Kevin Brice, USACE, Deputy District Engineer for Programs and Project Mgt.
Ms. Michelle McDowell, U.S. Fish and Wildlife Service, Pacific Region
Mr. David Wills, U.S. Fish and Wildlife Service, Columbia River Fisheries Program
STT Members
SSC Members
SAS Members

Double-crested Cormorant Management Plan to Reduce Predation of Juvenile Salmonids in the Columbia River Estuary

Draft Environmental Impact Statement

US Army Corps of Engineers ®
Portland District

Executive Summary

The Need for a Management Plan

In this Environmental Impact Statement the U.S. Army Corps of Engineers (Corps) is evaluating several alternatives to reduce predation-related losses of juvenile salmon (*Oncorhynchus* spp.) and steelhead (*O. mykiss*) from double-crested cormorants (*Phalacrocorax auritus*) nesting on East Sand Island in the Columbia River Estuary. Many of these juvenile salmon and steelhead (referred collectively hereafter as salmonids) are listed as threatened or endangered under the Endangered Species Act. Development and implementation of a management plan to reduce avian predation is a requirement under the Corps' consultation under the Endangered Species Act with the National Marine Fisheries Service of the National Oceanic and Atmospheric Administration (NOAA Fisheries) for the operation of the hydropower dams that make up the Federal Columbia River Power System. Management of double-crested cormorants is necessary to increase survival of juvenile salmonids by reducing predation-related losses. Over the past 15 years, double-crested cormorants on East Sand Island consumed approximately 11 million juvenile salmon and steelhead per year. When compared to other known mortality factors, this predation is considered a significant source of mortality to juvenile salmonids.

The Corps is the lead agency of the Environmental Impact Statement under the National Environmental Policy Act. The U.S. Fish and Wildlife Service, U.S. Department of Agriculture's Animal and Plant Health Inspection Service, Oregon Department of Fish and Wildlife, and Washington Department of Fish and Wildlife are cooperating agencies to the Environmental Impact Statement. The preferred alternative is the Corps' proposed management plan to comply with the 2014 Supplemental Federal Columbia River Power System Biological Opinion. The analyses in this Environmental Impact Statement will also help support decision-making within the cooperating agencies and other agencies, which have connected actions as a result of the implementation of the Corps' action. Three action alternatives (management plans) are considered in detail in the Environmental Impact Statement. Each alternative contains a set of actions, monitoring efforts, and potential adaptive responses that make up a management plan. Each alternative integrates non-lethal and lethal methods to manage the colony, with focus on one method as the primary management strategy.

Double-crested cormorants are native to the Columbia River Estuary. The colony on East Sand Island near the mouth of the Columbia River has increased from 100 breeding pairs in 1989 to approximately 15,000 breeding pairs in 2013. With a typical foraging range of

25 kilometers (Figure ES-1), the diet of double-crested cormorants on East Sand Island is made up mostly of marine forage fish. However, as juvenile salmonids migrate through the Lower Columbia River Estuary and past East Sand Island, double-crested cormorants consume them at high rates. Double-crested cormorant consumption of juvenile salmonids is highest in early May, which coincides with the peak nesting season.

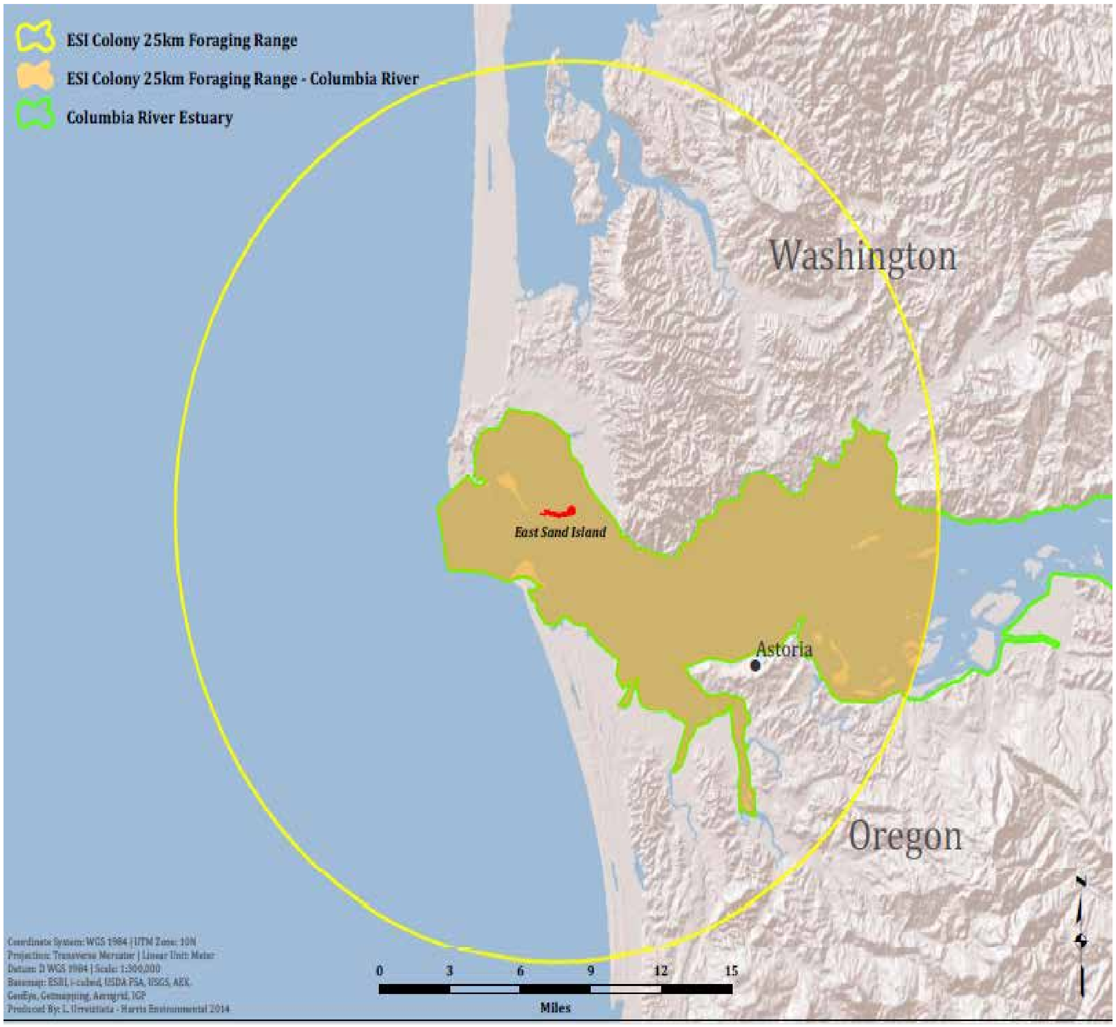


FIGURE ES-1. East Sand Island and the typical foraging range of nesting double-crested cormorants.

Management Objectives

Because of the documented adverse impacts to juvenile salmonids, management of the double-crested cormorant colony on East Sand Island was identified as a reasonable and prudent alternative action in the 2008 and associated 2010 and 2014 Supplements to the Federal Columbia River Power System Biological Opinion issued by NOAA Fisheries. For the 2014 Supplemental, NOAA Fisheries presented a "survival gap" analysis, which evaluated the difference in double-crested cormorant predation on juvenile steelhead between the "base period" of 1983–2002 and the "current period" of 2003–2009. Because steelhead are more susceptible to double-crested cormorant predation (compared to other salmonid species and in the context of the Biological Opinion), they were used to describe survival improvement targets that could be achieved through management of the double-crested cormorant colony on East Sand Island. NOAA Fisheries analysis determined that mortality of juvenile steelhead from double-crested cormorant predation was approximately 3.6 percent higher in the "current period" than the "base period."

NOAA Fisheries then determined that a reduced double-crested cormorant breeding population of 5,380 to 5,939 breeding pairs on East Sand Island would restore juvenile steelhead survival to the environmental baseline or "base period" levels. Thus, reasonable and prudent alternative 46 in the 2014 Supplemental Federal Columbia River Power System Biological Opinion called for the Corps to "…*develop a cormorant management plan (including necessary monitoring and research) and implement warranted actions to reduce cormorant predation in the estuary to Base Period levels (no more than 5,380 to 5,939 nesting pairs on East Sand Island).*" Reasonable and prudent alternative 46 specified the primary management objective for this Environmental Impact Statement and was written into the purpose of and need for action. The time period associated for implementation and achievement of management objectives is tied to the Biological Opinion, which identifies actions to begin by spring of 2015 and overall objectives to be achieved by the end of 2018. Regardless of prescribed timeframes, there is a strong need to implement actions as soon as possible to alleviate the significant source of mortality to juvenile salmonids from double-crested cormorant predation.

Putting Predation Impacts in Context

There are many causes of mortality to juvenile salmonids (Figure ES-2) as they move through the Columbia River Basin to the Pacific Ocean. In the context of other identified point-sources of mortality, such as hydropower dams, the mortality from predation by double-crested cormorants for some salmonid groups in the Columbia River Estuary is significant. For example, dam passage survival of steelhead and spring Chinook salmon at Bonneville Dam is required to be 96 percent (no more than 4 percent mortality). In 2011, estimated juvenile steelhead survival was higher than this, at 97.5 percent (or 2.5 percent mortality). This level of mortality from dam passage is approximately 2.7 times less than the 6.7 percent mortality for juvenile steelhead resulting from double-crested cormorant predation, as estimated in the NOAA Fisheries analysis in determining reasonable and prudent alternative 46. Higher mortality rates compared to the NOAA Fisheries analysis have been documented for some Columbia River salmonid groups in a given year (e.g., 11-17 percent; see Chapter 1, Section 1.2). Thus, for some salmonid groups, average double-crested cormorant predation impacts can be similar to or exceed the mortality experienced at a hydropower dam in the Federal Columbia River Power System, and, in some years, can be three to four times higher. Furthermore, recent research indicates juvenile salmonid mortality is highest in the lower 31 miles of the Columbia River (see Chapter 1, Section 1.2).

It is important to note that double-crested cormorant predation can differ dramatically within a given year and between years. During 2003–2013, when the colony size was relatively stable, estimates of total annual consumption ranged between 2.4 and 20.5 million. Factors that likely affect double-crested cormorant predation include environmental conditions that affect the timing, abundance, and availability of forage fish in the estuary (e.g., river discharge, tidal volume, sea surface temperature, upwelling timing, and strength), differences in double-crested cormorant abundance, nesting chronology, and nesting success, and large-scale climatic factors that influence both the prey and predator (e.g., El Niño Southern Oscillation, Pacific Decadal Oscillation, North Pacific Gyre Oscillation, and Pacific Northwest Index). These factors will be considered when predicting and interpreting the success of management actions on East Sand Island within a given year and over the long-term.

FIGURE ES-2. Juvenile salmon.

A Complex Issue

This Environmental Impact Statement proposes alternatives to manage the largest colony of double-crested cormorants in North America. Wildlife management is fundamentally a human concept. As the needs or goals of humans conflict with the needs of wildlife, there is an increasing "human dimension" to wildlife management. Individuals with an interest in the outcome of the management plan do not all share common values, nor will any one management action or alternative appease all stakeholders. The issues presented in this Environmental Impact Statement compose a complex problem, and the importance and relevance of the "human dimension" to finding an adequate solution cannot be overstated.

The differences in values held by the various stakeholders interested in the Corps' double-crested cormorant management plan were identified to some degree in the public scoping comments received. Many fisheries groups expressed concern that the problem has been left unaddressed for too long, that double-crested cormorant predation will only continue to increase, and the loss of personal income due to reduced fishing opportunities is unacceptable. Alternately, many wildlife groups commented that double-crested cormorants are being made scapegoats and suggested the Corps look at the true causes endangering salmon and steelhead runs, which these groups stated as overfishing, an excess of hatchery fish being released, and fish passage barriers such as the hydropower dams. While there were extremes in viewpoints, the Corps is seeking a balanced approach in addressing these competing considerations, needs, and recommended potential solutions to this complex wildlife management issue.

Designing Research to Guide Future Management

The Corps has conducted research to understand the dynamics of the double-crested cormorant colony on East Sand Island and aid in the development of appropriate alternatives for this Environmental Impact Statement. Social attraction techniques (setting up decoys and broadcasting audio playback of bird calls to encourage nesting) were tested within and outside the Columbia River Estuary for several years as a possible method to redistribute the East Sand Island double-crested cormorant colony. During 2004–2008, social attraction was employed on Miller Sands Spit and Rice Island with some success, primarily on Miller Sands Spit. During 2007–2012, social attraction techniques were used outside of the Columbia River Estuary at four known roosting sites in Oregon, but there were no nesting attempts made by double-crested cormorants.

In 2008 the Corps began to investigate the effectiveness of certain non-lethal methods to dissuade double-crested cormorants from nesting in specific locations on East Sand Island (Figure ES-3). Human hazing and use of visual deterrents was determined to be the most effective method to reduce the amount of available nesting habitat. In 2013, double-crested cormorants were restricted to just 4.4 acres of habitat, amounting to a 75 percent reduction of their preferred nesting area. Despite annual reductions in the amount of available nesting habitat, double-crested cormorants nested successfully on East Sand Island every year.

FIGURE ES-3. Cormorant colony on East Sand Island during dissuasion research.

Knowing where double-crested cormorants might relocate if dissuaded from nesting on East Sand Island was a high priority of dissuasion research during the last several years. As part of the studies, breeding adult double-crested cormorants were marked with radio or satellite transmitters. After some off-colony dispersal immediately following tagging, most returned to roost or nest on or near East Sand Island in the same year they were tagged and dissuaded from nesting. Double-crested cormorant use of areas during the breeding season was highest in the Lower Columbia River Basin, followed by the Washington Coast and Salish Sea (Table ES-1). Of all satellite-tagged cormorants hazed from East Sand Island prior to the 2012-2013 nesting seasons, 98 percent remained in the Columbia River Estuary for the nesting season.

TABLE ES-1. Visits of Satellite-tagged Double-crested Cormorants during March 1–September 30 (Years 2012 and 2013) and the Number of Active and Historical Colonies in Each Region.

Region	# of Birds that Visited	% of Birds that Visited	# of Detections	% of Detections	Active Colonies	Active + Historical Colonies
Oregon Coast	0	0.0%	0	0.0%	22	40
Lower Columbia River Basin	93	97.9%	976	59.7%	4	8
Washington Coast	61	64.2%	460	28.1%	4	32
Salish Sea	20	21.1%	144	8.8%	12	44
Vancouver Island Coast	4	4.2%	55	3.4%	0	0

Key Considerations in Developing Alternatives

The Corps considered many factors in determining how best to achieve the purpose and need (management goal) of this Environmental Impact Statement. Both double-crested cormorants and juvenile salmonids are natural components of the ecosystem and are protected under federal laws. Proposed management actions to double-crested cormorants must comply with the regulations implementing the Migratory Bird Treaty Act. Special considerations were given to the logistics of managing the large colony over a broad geographic area such as the Columbia River Estuary. Consideration was given on how to minimize potential impacts to other birds on and outside East Sand Island, a designated Important Bird Area by the American Bird Conservancy and the National Audubon Society, with upwards of 60,000 birds on the island during the nesting season.

Early in project planning, concerns were raised regarding redistribution of a large number of double-crested cormorants, and how other species and resources, as well as states, local agencies, and the public, might be affected should predation impacts be transferred to other areas. Dispersal of double-crested cormorants has the potential to cause greater impact to juvenile salmonids if they move to upriver locations in the Columbia River Estuary where juvenile salmonids compose a higher proportion of their diet. The Corps included extensive monitoring and adaptive management approaches into the alternatives to minimize double-crested cormorant dispersal and adverse effects to other regions.

How Alternatives Were Developed

The 2008 Federal Columbia River Power System Biological Opinion included a reasonable and prudent alternative to develop a double-crested cormorant management plan. A target colony size was not specified. In 2010, an interagency working group was formed to develop a management plan which included general alternatives to reduce double-crested cormorant predation, based on percent reductions (i.e., 25 percent, 50 percent, 75 percent, etc.). In July 2012 the Corps published its Notice of Intent which identified these various alternatives. Subsequently, the 2014 Supplemental Federal Columbia River Power System Biological Opinion identified a target colony size for East Sand Island.

The Corps further refined the alternatives based on comments from public scoping in late 2012 and through discussions with cooperating agencies. The Corps evaluated potential alternatives for their ability to meet the purpose of and need (management goal). However, only alternatives that were considered feasible in meeting the purpose of and need (management goal) were carried forward for detailed study.

Summary of Alternatives

Three action alternatives (including the preferred) and a no-action alternative are considered in detail (Table ES-2). Alternatives were developed as management plans. All employ an "integrated" approach (using a combination of non-lethal and lethal methods, but with focus on one or the other as a primary method). Alternatives employ a two-phased approach. Phase I involves efforts to directly reduce the size of the colony on East Sand Island to the target range set in reasonable and prudent alternative 46 in the 2014 Supplemental Federal Columbia River Power System Biological Opinion (5,380 to 5,939 breeding pairs). Phase II involves efforts to ensure the target colony size is not exceeded and to evaluate the success of management. This would be done by monitoring peak annual size of the East Sand Island colony and recovery of salmonid passive integrated transponder tags deposited by double-crested cormorants within the colony. Passive integrated transponder tags are inserted into fish and allow for assessment of juvenile salmonid mortality resulting from the East Sand Island double-crested cormorant colony.

TABLE ES-2. Comparison of Alternatives.

Alternative	Summary of Actions	Monitoring	Adaptive Management
Alternative A No Action	No actions would occur to manage the colony on East Sand Island. The Corps would not meet its statutory responsibilities to fulfill reasonable and prudent alternative 46. Survival improvements for juvenile salmonids would need to be made up with other actions within the purview of the Federal Columbia River Power System.	n/a	n/a
Alternative B Non-Lethal Management Focus with Limited Egg Take	Phase I - Use primarily non-lethal methods to achieve target colony size of ~5,600 double-crested cormorant breeding pairs by dispersing >7,250 breeding pairs off East Sand Island over a 4-year period. Incremental dispersal (approximately 2,000-3,000 pairs per year) would occur by reducing available acreage incrementally and hazing elsewhere on the island to preclude nesting. An application for a depredation permit for minimal egg take on East Sand Island (500 eggs) and in the Columbia River Estuary (250 eggs) would be submitted to USFWS annually to support the effectiveness of hazing efforts after the beginning of the breeding season. Off-island land- and boat-based hazing could occur throughout the Columbia River Estuary. Boat-based and land-based monitoring and hazing efforts within the Columbia River Estuary concurrent with management actions on East Sand Island through July 31. Five to eight boat crews would survey and haze	Phase I - Tiered approach at monitoring (daily, weekly, and monthly as necessary) via aerial, boat-, and land-based surveys to measure peak colony size and detect movement of double-crested cormorants in the Columbia River Estuary. Aerial and ground monitoring on East Sand Island to determine abundance and response of double-crested cormorants and other birds. Recovery of passive integrated transponder tags after the breeding season to assess fish mortality. Outside the Columbia River Estuary, abundance surveys in the Columbia Basin above the Bonneville Dam and in coastal areas in Washington and Oregon would occur at least once a year during the peak breeding season. Phase II - Monitoring on East Sand Island and Columbia River Estuary would decrease in frequency depending on information needs.	Corps would convene Adaptive Management Team with cooperating agencies to meet as needed during implementation. Monitoring results would be used to determine need for in-season and between year adjustments in field techniques, including reduction in available habitat, hazing techniques, and egg take numbers. Monitoring frequency and locations adjusted based on information needs. If aerial surveys are not sufficient in assessing dispersal, individual marking techniques (i.e., primarily satellite tags, but also VHF radios and bands) could be used.

Alternative	Summary of Actions	Monitoring	Adaptive Management
	double-crested cormorants throughout the Columbia River Estuary. Phase II - Terrain modification to inundate the western portion of the island and preclude nesting, combined with continued monitoring and hazing efforts, supported with limited egg take, as needed, to ensure the colony target size is not exceeded. A colony size of ~5,600 breeding pairs could remain. No management actions would be taken to ensure a minimum colony size.	No annual abundance surveys in the Columbia Basin above the Bonneville Dam and in coastal areas in Washington and Oregon. Outside of the Columbia River Estuary, monitoring would match or supplement the Pacific Flyway Monitoring Strategy, which calls for monitoring at select sites every three years.	
Alternative C Culling with Integrated Non-Lethal Methods Including Limited Egg Take *(Preferred Management Plan)*	Phase I - Culling of individuals to achieve target colony size of ~5,600 breeding pairs. Culling would occur over 4 years, with the ability to achieve the target size in a shorter duration (3 or 2 years) under Adaptive Management. Under the 4-year strategy, 20.3 percent of the colony would be culled per year. In total, 15,955 double-crested cormorants would be taken in all years (5,230, 4,270, 3,533, and 2,923 double-crested cormorants in years 1 to 4, respectively). The Corps would submit an annual depredation permit application to the USFWS for the proposed individual take levels and associated nest loss from take of those individuals. Take would occur on- and off-island within the foraging range (25km) of the East Sand Island colony. Concurrent with culling, hazing supported with limited egg take would occur to prevent colony expansion on the island, along with land- and boat-based hazing and efforts to prevent double-crested cormorants from	Phase I - The same tiered monitoring on and off East Sand Island as Alternative B would occur. Take levels would be reported annually with more informal reporting as needed. Similar to Alternative B, abundance surveys in the Columbia Basin above the Bonneville Dam and in coastal areas in Washington and Oregon would occur at least once a year during the breeding season. Monitoring in the Columbia River Estuary would occur 2 to 3 days after a culling session and be used to assess potential dispersal to areas in the Columbia River Estuary, particularly upstream of the typical double-crested cormorant foraging range (25 km) of East Sand Island. Monitoring could decrease in frequency once take commences. Less than five boat crews would be needed.	Same Adaptive Management Team and adjustments to non-lethal techniques and monitoring as described in Alternative B, except no individual marking would occur. The adjusted 3-year or 2-year strategy could be selected if the proposed take levels for the respective strategy are expected to be achieved by June 26- (approximate mid-point of when active nests are typically present on East Sand Island) and the frequency of culling to achieve the proposed take levels would not exceed the lower dispersal

Alternative	Summary of Actions	Monitoring	Adaptive Management
	relocating in the Columbia River Estuary, similar to Alternative B. Phase II - Same as Alternative B.	Phase II - Same as Alternative B.	threshold (observed abundance 70 percent or less than expected abundance one week after a culling session). Take percentage in year 2 and 3 could be increased to 28.8 percent for the adjusted 3-year strategy (6,071 and 4,489 double-crested cormorants taken and associated active nests lost in year 2 and 3) or 48.0 percent for the adjusted 2-year strategy (10,156 double-crested cormorants taken and associate active nests lost in year 2). Selecting June 26 as a measure for adjusting future take levels would be contingent upon implementation occurring as planned. If this level of take could likely occur by June 26, the Corps, in consultation with the Adaptive Management Team, would then consider adjusting year strategies.
Alternative D Culling with Exclusion of Double-crested	Phase I - Same as Alternative C. Phase II - The same primarily non-lethal methods described in Phase II of Alternatives B and C (terrain modification, supplemented with hazing supported	Phase I - Same as Alternative C. Phase II - Same as Phase I of Alternative B initially, but would transition to Phase II of Alternative B and C.	Phase I - Same as Alternative C. Phase II - Same as Phase I of Alternative B initially, but would transition to Phase II of

Alternative	Summary of Actions	Monitoring	Adaptive Management
Cormorant Nesting on East Sand Island in Phase II	with limited egg take, as necessary) would be used to disperse all remaining double-crested cormorants (~5,600 breeding pairs) from East Sand Island and exclude future double-crested cormorant nesting. Hazing efforts in the Columbia River Estuary would be the same as Phase I of Alternative B.		Alternative B and C.

Summary of Resources in Affected Environment

Because double-crested cormorants are migratory birds and use a large area and action alternatives proposed in the Environmental Impact Statement are expected to cause some dispersal, the affected environment encompasses a large geographic area. This area includes the coastal and interior areas from northern California (San Francisco Bay) to southern British Columbia (Vancouver Island Coast) and the entire states of Oregon and Washington. Nearly all of the documented post-breeding and wintering locations of double-crested cormorants marked on East Sand Island as part of past monitoring efforts were found within this area. The affected environment is summarized below (Table ES-3):

TABLE ES-3. Affected Environment.

Affected Resource	Summary
Vegetation and Soils of East Sand Island	A mix of native and non-native plant species is found on the island. Several tidal and non-tidal wetlands and forested areas are present. Guano from double-crested cormorants on the western portion of the island has adversely affected vegetation establishment. Soils are generally sandy to sandy silt.
Double-crested Cormorants	The double-crested cormorant colony on East Sand Island has grown from approximately 100 breeding pairs in 1989 to approximately 15,000 breeding pairs in 2013. The colony accounts for approximately 40 percent of the western population of double-crested cormorants, which includes the breeding colonies from British Columbia to California and east to the Continental Divide. Although the western population of double-crested cormorants composes a small percentage of the continental population, the breeding colony on East Sand Island is the largest in North America. The coastal states and provinces account for greater than 90 percent of the western population, with approximately 70 percent of the breeding population along the coast. From 1987–1992 to approximately 2009, the number of double-crested cormorant breeding pairs estimated within coastal states and provinces increased by approximately 72 percent (i.e., 3 percent per year), or 12,000 breeding pairs, with most growth occurring at the East Sand Island colony. Large-scale distributional changes occurred, largely as a result of growth at East Sand Island.
Other Birds on East Sand Island	Gulls, Caspian terns, Brandt's cormorants, and California brown pelicans are present in large numbers on the island. Several raptors (eagles, owls, and falcons) are also present on the island, foraging on eggs, chicks, and adult birds. Waterfowl and shorebirds frequent the island to roost and forage, although in far fewer numbers than nesting colonial waterbirds. Shorebirds are observed in the tidal flats and beaches, and a variety of songbirds are present in the more vegetated areas on the central portion of the island. Most, if not all of these birds, overlap with double-crested cormorants throughout the affected environment.

Affected Resource	Summary
Other Birds	As a result of recent listing under the Endangered Species Act and the designation of critical habitat on nearby islands where double-crested cormorants are expected to prospect for new habitat, streaked horned larks are the species of most concern off of East Sand Island. American white pelicans and pelagic cormorants nest in the Columbia River Estuary. Along the Pacific Coast and Salish Sea, a number of other birds may overlap with double-crested cormorants, including auklets, petrels, puffins, oystercatchers, herons, and pigeon guillemot.
ESA-Listed Fish in the Lower Columbia River Basin	Six fish species, representing fifteen different Evolutionary Significant Units or Distinct Population Segments listed under the Endangered Species Act, occur in the Lower Columbia River Basin and are potential prey to double-crested cormorants. Direct mortality from avian predation, including double-crested cormorant predation, is identified in certain Endangered Species Act recovery plans as a secondary factor limiting viability for all Lower Columbia River coho, late fall and spring Chinook salmon and steelhead populations; a key limiting factor affecting all Middle Columbia River steelhead populations and Upper Willamette River Chinook and steelhead; and a threat to Upper Columbia River spring Chinook and steelhead populations. On average, double-crested cormorants have consumed approximately 11 million Columbia River Basin juvenile salmonids per year over the last decade.
Other ESA-Listed Fish	Oregon Coast coho and Southern Oregon and Northern California coho are found along the Oregon Coast. Puget Sound steelhead and Chinook, Hood Canal chum, Ozette Lake sockeye, and three species of rockfish (bocaccio, canary, and yelloweye) are found along the Washington Coast and Salish Sea areas. Bull trout and Pacific eulachon are widely distributed throughout the affected environment. All of these species are listed under the Endangered Species Act.
Public Resources	Public resources that were identified as having potential impacts from management actions include: public health and human safety, as it related to possible exposure to concentrations of double-crested cormorant guano and use of firearms under lethal take strategies; transportation facilities, particularly the Astoria-Megler Bridge (i.e., double-crested cormorants roosting or nesting on bridges, docks, airports, etc.); and dams and hatcheries, where double-crested cormorants congregate and predate upon juvenile salmonids.
Columbia River Basin Salmon Fisheries	Columbia River in-river commercial, tribal, and recreational fisheries are important regional economic contributors. Equally important is the cultural importance of salmon as a "first food" for Columbia River tribes. Hatchery production supplements the wild origin fish, supporting fisheries and conservation of the species. An estimated $49.1 million personal income in 2012 dollars was generated by hatchery surpluses (2%), tribal commercial (16%), non-Indian commercial (15%), and freshwater sport recreational (68%) Columbia River in-river fisheries. Columbia River tribes contribute greatly to the production of hatchery fish. The value of tribal ceremonial and subsistence harvests cannot be measured in terms of dollars and are culturally significant beyond economic gain.
Historic Properties	Four historic properties have been recorded on the island; two are associated with stabilization efforts (a basalt rock armored shoreline and an associated equipment bone

Affected Resource	Summary
	yard), and two are associated with the Harbor Defense System of World War II. Prior to a 1930s stabilization effort the island was a shifting sandbar and did not exist in its current configuration.

Summary of Environmental Consequences

Alternative A: No Action

If no actions are taken to manage the double-crested cormorant colony, predation rates on juvenile salmonids would likely remain higher than rates estimated during the environmental baseline of the 2008 Federal Columbia River Power System Biological Opinion and would continue to be a significant source of mortality. Additional measures would need to be identified to fill the gap in juvenile salmonid survival. These measures are unspecified at this time but would need to demonstrate a 3.6 percent increase in juvenile steelhead survival per the purpose and need. These actions could have potentially significant environmental and economic impacts given the magnitude of double-crested cormorant predation and the required survival improvement. Since these actions are unknown at this time, it would be speculative to evaluate the potential environmental and social effects. Therefore the no action alternative in this document describes the effects that could continue to occur if no efforts were taken to manage the double-crested cormorant colony on East Sand Island per the revised reasonable and prudent alternative 46.

Double-crested cormorant predation would continue to be a significant cause of juvenile salmonid mortality, with 11 million juvenile salmonids being consumed on average annually and potential predation rates as high as 17 percent on particular salmonid groups within a given year. Average size of the double-crested cormorant colony on East Sand Island (approximately 13,000 breeding pairs) and abundance of the western population of double-crested cormorants (approximately 31,200 breeding pairs) would presumably remain similar to current estimates in the near term. Future growth of the East Sand Island colony and the western population of double-crested cormorants would continue on current trends. The East Sand Island colony would continue to account for approximately 40 percent (13,000/31,200) of the western population.

Vegetation and soils within the 16 acres of the double-crested cormorant colony would continue to be impacted by guano, resulting in the western end of the island largely denuded from vegetation and species diversity reduced. Colony size and abundance of other bird species on and off East Sand Island would remain similar to current estimates, and spatial distribution of other nesting species would remain similar. The annual economic value of in-river Columbia River fisheries would likely remain similar to current levels in the near-term ($41.0 million direct financial value [i.e., revenue received by harvesters and expenditures made by anglers]; $48.4 million regional economic impact [i.e., expenditures as related to personal income and jobs]). Predation from the double-crested cormorant colony on East Sand Island would likely continue to result in a loss of up to $21 million in direct financial investment in hatchery production and potential annual losses of $2.7 million to in-river Columbia River fisheries. Direct or indirect adverse effects to public resources would be similar to past conditions before dissuasion research, which potentially increased dispersal of double-crested cormorants. There would be no adverse effects to historic properties, since there would be no ground disturbance on the island. Direct or indirect effects to threatened or endangered fish outside of the Lower Columbia River Basin would be similar to past conditions before dissuasion research.

Alternative B: Non-Lethal Management Focus with Limited Egg Take

If hazing and habitat reduction reduce the colony to approximately 5,600 pairs within 4 years, vegetation and soils may experience passive restoration in the short term, although dissuasion activities could adversely impact soils and vegetation while managing the colony. Later modification of the terrain would likely cause conversion of current bare sand to tidal mudflat or marsh areas, which may increase diversity of vegetation and soil complexity. Terrain modification may adversely affect two recorded historic properties on the island: the basalt rock armor, as the result of the removal of rock; and the World War II observation tower, as a result of increased tidal inundation.

Although the size of the double-crested cormorant colony on East Sand Island would be reduced through dispersal, the abundance of the western population of double-crested cormorants would likely remain similar to, or decrease from, current estimates (approximately 31,200 breeding pairs) in the near term. Future growth of the western population of double-crested cormorants could be reduced compared to current rates, as growth at East Sand Island would be limited. There may be a depression in recruitment prior to the successful breeding of individuals at new sites or if productivity at new sites is lower than at East Sand Island. Approximately 18 percent (5,600/31,200) of the western population of breeding double-crested cormorants would be nesting at East Sand Island. Non-target species common to the island have the greatest potential for experiencing adverse effects. These effects would likely result from island-wide hazing, which is necessary to exclude double-crested cormorants greater than the target size from nesting. There is high potential for a significant reduction in abundance or the exclusion of nesting of Brandt's cormorants on East Sand Island as a consequence of management because they nest in close association with double-crested cormorants. There is a moderate to high potential for a significant reduction in colony size or abundance of other waterbird species (gulls, pelicans, and terns) on East Sand Island. There is a possibility that other species may completely abandon East Sand Island after repeated hazing, as well as a potential for inter-specific competition.

The potential for adverse effects off of East Sand Island is dependent upon and commensurate with dispersal levels to new areas and subsequent site-specific interactions. Within the Columbia River Estuary, there is potential for hazing to occur in new areas or to intensify in existing areas where hazing already occurs (i.e., upland dredged disposal areas on estuary islands). The greatest potential for adverse effects to other birds off of East Sand Island is the potential for hazing to affect streaked horned larks. Pelagic cormorants and American white pelicans also overlap with double-crested cormorants in the Columbia River Estuary and could be affected by hazing activities.

Reduction of the double-crested cormorant colony size to approximately 5,600 pairs is expected to reduce the rate of predation necessary to eliminate the survival gap identified by NOAA Fisheries, resulting in average annual juvenile salmonid survival increases of 1 to 4 percent, depending on Evolutionarily Significant Unit and Distinct Population Segment. These benefits are not expected to be fully realized from Alternative B in the short term, however, because hazing is unlikely to be 100 percent effective in keeping double-crested cormorants out of the Columbia River Estuary. For threatened and endangered fish outside of the Lower Columbia River Basin, potential adverse effects are the greatest for salmonid species in freshwater and estuary habitats that occur within the foraging range of double-crested cormorant breeding colonies. There is also potential for adverse effects in double-crested cormorant high use areas, particularly along the Washington coast and Salish Sea. Potential impacts to fish in these areas, however, may be less, given the size and life history of Pacific eulachon, rockfish species, bull trout, Puget Sound steelhead, and Hood Canal chum. Puget Sound Chinook salmon may be more vulnerable due to their extended use of estuaries and nearshore marine environments.

Proposed reduction in the colony size and the associated reduction of in-river Columbia River salmonid predation could result in increases of annual direct financial value and regional economic impacts of 3.6 percent ($1.5 million) and 3.1 percent ($1.5 million), respectively. Similar to survival benefits, economic benefits are not expected to be fully realized, at least in the short term, because hazing is not expected to be 100 percent successful in keeping double-crested cormorants out of the Columbia River Estuary. Persistent use of the Astoria-Megler Bridge by double-crested cormorants throughout the breeding season is expected, and there could be high potential for adverse effects from associated guano corrosion. Effects to other transportation structures, dams, and hatcheries would be commensurate with dispersal levels to new areas. No adverse effects to human health and safety are expected, as little direct contact between humans and double-crested cormorants would be expected and disease transmission is unlikely to occur.

Alternative C: Culling with Integrated Non-Lethal Methods Including Limited Egg Take *(Preferred Alternative/Management Plan)*

With reduction of the double-crested cormorant colony on East Sand Island primarily occurring as a result of culling, potential off-colony effects from dispersal and hazing would be substantially lower in Alternative C than with redistribution (Alternative B). The effects to vegetation and historic properties would be the same as Alternative B, as the result of terrain modification. Effects from a 4-year culling program (or adaptively adjusted 3- or 2-year program in subsequent years) is expected to reduce the western population of double-crested cormorants to approximately 23,250 breeding pairs (approximately 2,500 breeding pairs greater than ca. 1990 abundance [20,830 breeding pairs]) after Phase I and could potentially reduce future growth rates. Since 1990, the growth of the western population of double-crested cormorants has been primarily associated with the growth of the East Sand Island colony. Thus, it appears that the western population of double-crested cormorants is sustainable at approximately ca. 1990 numbers. A sustainable population is defined for this analysis as a population that is able to maintain numbers above a level that would not result in a major decline or cause a species to be threatened or endangered. Approximately 24 percent (5,600/23,250) of the western population of breeding double-crested cormorants would be at East Sand Island under this alternative.

There is a low potential for overall double-crested cormorant use and hazing outside the area where nesting occurs. The potential is moderate to high during the primary period of lethal take on-island, which likely would be 2 to 3 weeks. Due to the potential for misidentification, there is a potential for take of up to approximately 0.1 to 0.2 percent of the regional population of Brandt's cormorants per year under the 4-year strategy, or approximately 3 to 5 percent of the colony on East Sand Island per year (i.e., colony is approximately 1,600 breeding pairs). If take levels increase in subsequent years under adaptive management, take levels could be as high as 0.4 percent of the regional population and 10 percent of the colony on East Sand Island in year 2 under the adjusted 2-year lethal strategy. There is high potential for a substantial reduction in the size of the Brandt's cormorant colony on East Sand Island. There would be a low to moderate potential for a substantial reduction in colony size of other species and a low potential for species to abandon East Sand Island.

The expectation for double-crested cormorant dispersal is low under this alternative. Because the end target colony size is the same as Alternative B, the potential range of survival benefits for juvenile salmonids (1 to 4 percent annual increase, depending on Evolutionarily Significant Unit and Distinct Population Segment) and economic benefits (increases of annual direct financial value and regional economic impacts of 3.6 percent ($1.5 million) and 3.1 percent ($1.5 million), respectively) could be the same as Alternative B. However, the expectation is that benefits from Alternative C would be fully realized, particularly in the short-term, because dispersal in the Columbia River Estuary would be minimal. The reduction in predation associated with the colony target size would likely be achieved under Alternative C, whereas this is less likely under Alternative B. There is a much lower potential to realize adverse effects to other species or public resources off of East Sand Island, as compared to Alternative B. Streaked horned larks are the primary species of concern; however, additional hazing, beyond what is currently done for the Corps' navigation program, is not expected. Effects to other birds or fish in the affected environment would likely remain similar to existing conditions. Due to the potential for misidentification, there is a potential for take of up to 0.03 to 0.05 percent of the regional population of pelagic cormorants per year under the 4-year strategy, or up to 6 to 10 percent of the colony in the Columbia River Estuary (i.e., colony is approximately 75 to 100 breeding pairs) per year. If take levels increase in subsequent years under adaptive management, take levels could be as high as 0.1 percent of the regional population and 20 percent of the population in the Columbia River Estuary in year 2 under the adjusted 2-year lethal strategy. However, take levels of pelagic cormorants are expected to be lower than the upper range analyzed due to proposed field techniques.

Alternative D: Culling with Exclusion of Double-crested Cormorant Nesting on East Sand Island in Phase II

Alternative D is identical to Alternative C in Phase I, and effects described under Alternative C, both on and off of East Sand Island, would be the same for Alternative D in the short term (2 to 4 year period of culling). Abundance of the western population of double-crested cormorants is expected to be reduced to approximately 23,250 breeding pairs (approximately 2,500 breeding pairs greater than ca. 1990 abundance) after Phase I, and future growth rates could be reduced even more than Alternative C. The western population of double-crested cormorants appears sustainable (as defined in Alternative C) at approximately ca. 1990 abundance (20,830 breeding pairs). The key difference in Alternative D is that non-lethal management would be used to exclude double-crested cormorants from nesting on East Sand Island after Phase I colony size is attained. This would result in a substantial effect to the distribution of the western population of double-crested cormorants and potentially greater, or similar, effects to those described in Phase I of Alternative B, where redistribution of the colony is proposed. Precluding all double-crested cormorant nesting on East Sand Island would likely have greater effects to the western population of double-crested cormorants compared to just redistributing a portion of the colony. Effects would become less if dispersed double-crested cormorants breed at new sites outside of the Columbia River Estuary.

The broad scale hazing effort in the Columbia River Estuary, as discussed in Phase I of Alternative B, would occur under Phase II of Alternative D. Key differences in the potential effects of this alternative compared to others are the greater benefits for juvenile salmonid survival increases, as well as the expected economic benefits in the long-term. These benefits may be substantially higher in the long-term than other alternatives, should double-crested cormorants be completely excluded from the Columbia River Estuary, resulting in potentially zero double-crested cormorant predation impacts, although this may not be realized for many years after Phase II. With no double-crested cormorant nesting on East Sand Island, average annual juvenile salmonid survival increases of 2 to 8 percent (depending on Evolutionarily Significant Unit and Distinct Population Segment) and economic increases to in-river Columbia River fisheries of 3.6% ($1.5 million; annual direct financial value) and 3.1% ($1.5 million; regional economic impact) may be realized.

The Preferred Alternative/Management Plan

The Council on Environmental Quality defines the agency's preferred alternative as "the alternative which the agency believes would fulfill its statutory mission and responsibilities, giving consideration to economic, environmental, technical and other factors." Alternative C was identified as the preferred alternative and management plan after evaluating the environmental consequences of each alternative when compared to the technical and logistical feasibility of reducing predation impacts throughout the Columbia River Estuary. In fulfilling the Corps' statutory responsibilities, Alternative C best meets the consultation requirements under the Endangered Species Act as identified by the 2014 Federal Columbia River Power System Supplemental Biological Opinion.

Because Alternative C proposes a reduction in colony size through culling, there is more certainty that this alternative would meet the need of reducing double-crested cormorant predation throughout the Columbia River Estuary than Alternatives B and D, which propose abundance reduction through dispersal. Minimal double-crested cormorant dispersal is expected under Alternative C given proposed field techniques and knowledge from other similar programs. This alternative has the greatest certainty of having least direct and indirect adverse effects to non-target species and resources off East Sand Island, particularly streaked horned larks, which would likely be adversely affected by high levels of double-crested cormorant dispersal and associated hazing activities within the Columbia River Estuary.

Alternative C has the lowest associated dollar costs for implementation and, given the breadth of the Columbia River Estuary, the greatest certainty that indefinite commitment of resources would not be needed to achieve the level of predation reduction specified in reasonable and prudent alternative 46. Alternative C is expected to have greater direct adverse effects to individual double-crested cormorants and the double-crested cormorant colony on East Sand Island than Alternative B, but less than Alternative D. Under Alternative C, abundance of the western population of double-crested cormorants is expected to be greater than ca. 1990 abundance. Since 1990, the growth of the western population of double-crested cormorants has been primarily associated with the growth of the East Sand Island colony. Thus, it appears that the western population of double-crested cormorants is sustainable at approximately ca. 1990 numbers. A sustainable population is defined for this analysis as a population that is able to maintain numbers above a level that would not result in a major decline or cause a species to be threatened or endangered.

Public Review and Comment

The Corps is seeking public comment on the draft Environmental Impact Statement. The comment period is intended to provide those interested in or affected by this action with an opportunity to make their concerns known. Specifically, the Corps is seeking input that can inform our decision or analysis. After receiving public comments, the Corps and cooperating agencies will address substantive comments and incorporate them into a final Environmental Impact Statement.

Comment Timeframe: Comments will be accepted for 45 days from publication of the Notice of Availability of the draft Environmental Impact Statement in the Federal Register by the U.S. Environmental Protection Agency. This is anticipated to be June 19, 2014. Written comments may be sent electronically or by traditional mail to:

Sondra Ruckwardt
U.S. Army Corps of Engineer District, Portland
Attn: CENWP-PM-E-14-08/Double-crested Cormorant draft EIS
P.O. Box 2946
Portland, Oregon 97208-2946

Send electronic comments to **cormorant-eis@usace.army.mil**

Table of Contents

List of Tables

List of Figures

List of Acronyms

AM	Adaptive Management
BiOp	Biological Opinion
BMP	Best Management Practice
BPA	Bonneville Power Administration
BOR	Bureau of Reclamation
BRNW	Bird Research Northwest
Corps	United States Army Corps of Engineers
CRCIP	Columbia River Channel Improvement Project
CRFM	Columbia River Fish Mitigation
CRITFC	Columbia River Inter-Tribal Fish Commission
DCCO	Double-crested Cormorant
DEIS	Draft Environmental Impact Statement
DPS	Distinct Population Segment
DDT	Dichlorodiphenyltrichloroethane
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
ESA	Endangered Species Act
ESU	Evolutionary Significant Unit
FCRPS BiOp	Federal Columbia River Power System Biological Opinion
FCRPS	Federal Columbia River Power System
FEIS	Final Environmental Impact Statement
GIS	Geographic Information Systems
LiDAR	Light Detection and Ranging
MBTA	Migratory Bird Treaty Act
MSA	Magnuson–Stevens Fishery Conservation and Management Act
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOAA Fisheries	NOAA's National Marine Fisheries Service
NWR	National Wildlife Refuge
O & M Program	Corps' Columbia River Channel Operation and Maintenance Program

ODFW	Oregon Department of Fish and Wildlife
PRDO	Public Resource Depredation Order
RM	River Mile
RPA	Reasonable and Prudent Alternative
USACE	United States Army Corps of Engineers
USDA-WS	United States Department of Agriculture - Wildlife Services
USFWS	United States Fish and Wildlife Service
WDFW	Washington Department of Fish and Wildlife
WRDA	Water Resources Development Act

Glossary of Terms

Affected Environment. Geographic scope of analysis for EIS includes coastal areas from northern California (37°24’00”) to southern British Columbia (51°00’00”) and the states of Washington and Oregon

Anadromous. Fish that migrate from the ocean to fresh water to spawn (breed)

Base Period. The time period (1983–2002) used to establish a baseline of productivity for salmon and steelhead within the FCRPS Biological Opinion

Clutch. The complete set of eggs produced or incubated at one time

Columbia River Estuary. The region on the Columbia River influenced by ocean tides, extending upriver to Bonneville Dam at River Mile 146 and to the Willamette Falls, south of Portland, at River Mile 26 on the Willamette River (a major tributary to the Columbia River)

Colony. A group of birds nesting or roosting in the same area

Current Period. The time period (2003–2009) used to establish current productivity for salmon and steelhead within the FCRPS Biological Opinion

Designated Colony Area. Area made available to double-crested cormorants (DCCOs) for nesting, which would not be hazed or modified

Direct Financial Value. Revenue received by harvesters and expenditures made by anglers, which are linked with the availability of Columbia River Basin production returning adults

Dissuade. To discourage from nesting

Dredged material. Any excavated material from waterways

Effigies. A likeness of a natural predator

Estuary. The wide part of a river where it nears the sea; fresh and salt water mix

Federal Columbia River Power System. Hydro-electric dams that are owned and operated by the federal government on the Columbia River

Foraging habitat. The area where an animal searches for food and provisions

Fry. The young of any fish

Habitat. The type of environment in which an organism or group normally lives or occurs

Habitat Modification. Any measure taken to change the way habitat can be used by DCCOs in order to make it unsuitable for that use

Hazing. Any non-lethal activity that discourages nesting, roosting, and foraging behavior, such as using visual and noise deterrents, habitat modification, boats or other similar equipment, or any other dispersal technique

Inter-specific Competition. Competition between different species over the same resources, such as food, water and habitat

Sub-regions of Affected Environment. The area within the affected environment that is most likely to be affected by management actions; includes the Lower Columbia River Basin and Estuary, and the coasts of Oregon, Washington and British Columbia

Marsh. Wetlands frequently inundated with water, which are principally composed of emergent soft-stemmed plants adapted to saturated soils; may also include small amounts of shrub or tree cover

Out-migrating. Juvenile fish migrating out of their native rivers or streams toward ocean waters

Pacific Flyway. Major north-south flight path for migratory birds, extending from the North Slope of Alaska to Central and South America

Pacific Region. Refers to the regional population of the Seabird Conservation Plan; includes Washington, Oregon and California

Pelagic. Of or pertaining to the ocean; applied especially to animals that live at the surface of the ocean, away from the coast

Pile dike. Dike with pilings

Piscivorous. Fish-eating

PIT tag. Passive Integrated Transponder tag; very small (12 mm by 2.1 mm) glass encapsulated tube containing a microchip inserted into a fish's body cavity. PIT tags remain inactive until activated by an electrometric field to transfer data

Prospecting. To search for nesting habitat

Regional Economic Impact. An estimate of the level of economic activity being generated within a specified geographic region, stemming from changes being made to expenditures within that region

River Mile. A measure, in miles, of distance along a river, from its mouth

Salmonid. Of, belonging to, or characteristic of the family Salmonidae, which includes salmon, trout, char, whitefish, and other coldwater fishes

Smolts. Juvenile salmonids migrating to the sea for the first time

Sub-yearling. A juvenile fish, less than 1 year old

Spawner. A fish that has produced fry

Take. (MBTA regulatory definition) To pursue, hunt, shoot, wound, kill, trap, capture, or collect, or the attempt to pursue, hunt, shoot, wound, kill, trap, capture, or collect

Waterbirds. Birds that obtain all or most of their food from the water

Western Population. The breeding population of DCCOs within British Columbia, Washington, Oregon, Idaho, California, Nevada, Utah, Arizona, and portions of Montana, Wyoming, Colorado, and New Mexico that lie west of the Continental Divide; a management population within the Pacific Flyway; the affected environment (see above) lies within the boundary of the western population

Yearling. A fish that is 1 year old or has not completed its second year

Chapter 1 Purpose of and Need for Action

1.1 Introduction

This Draft Environmental Impact Statement (DEIS) describes and evaluates several alternatives the U.S. Army Corps of Engineers (Corps), lead agency under the National Environmental Policy Act (NEPA), are considering for increasing survival of Endangered Species Act (ESA)-listed juvenile salmonids, by reducing double-crested cormorant (*Phalacrocorax auritus;* DCCO) predation of juvenile salmonids in the Columbia River Estuary. Each alternative contains a set of actions, monitoring efforts and adaptive responses that make up a management plan. This chapter provides a brief introduction, establishes the geographic scope for analysis, defines the purpose and need, identifies the lead and cooperating agencies and their roles in developing this document, and discloses issues that arose during scoping.

1.1.1 East Sand Island

East Sand Island is in the state of Oregon (Clatsop County), near the mouth of the Columbia River (River Mile 5) approximately 1 mile west of Chinook, Washington and 10 miles northwest of Astoria, Oregon (Figure 1-1). The island is approximately 60 acres in size, for the area above the high tide mark. The Corps is the federal land manager of East Sand Island and 36 Code of Federal Regulations (CFR) Part 327 applies to its use as public land.

Historically, East Sand Island was connected to the larger Sand Island in Baker Bay. In 1863, the United States Army obtained Sand Island for military purposes. In the early 1940s, the island separated into eastern and western portions, due to erosion. The island's present configuration was established during the 1940s and 1950s in an attempt to stabilize the island and prevent further erosion. Stabilization was achieved through the implementation of a pile dike system, installation of riprap, and targeted placement of dredged material. In 1954, 1,249 acres were transferred to the Corps for the Sand Island Channel Improvement Project.

Two dredged material placement events occurred on East Sand Island in the late 1970s and early 1980s. The material was dredged during maintenance on the Chinook Channel. Over 650,000 cubic yards of material was placed on the eastern portion of the island during these events (NOAA 2012). The island is no longer used as a disposal site for dredged material. The island was stabilized with riprap on the south beach to prevent additional erosion. East Sand Island continues to play an important role in maintaining the stability of the Columbia River federal navigation channel and port access to the Chinook Channel and Baker Bay.

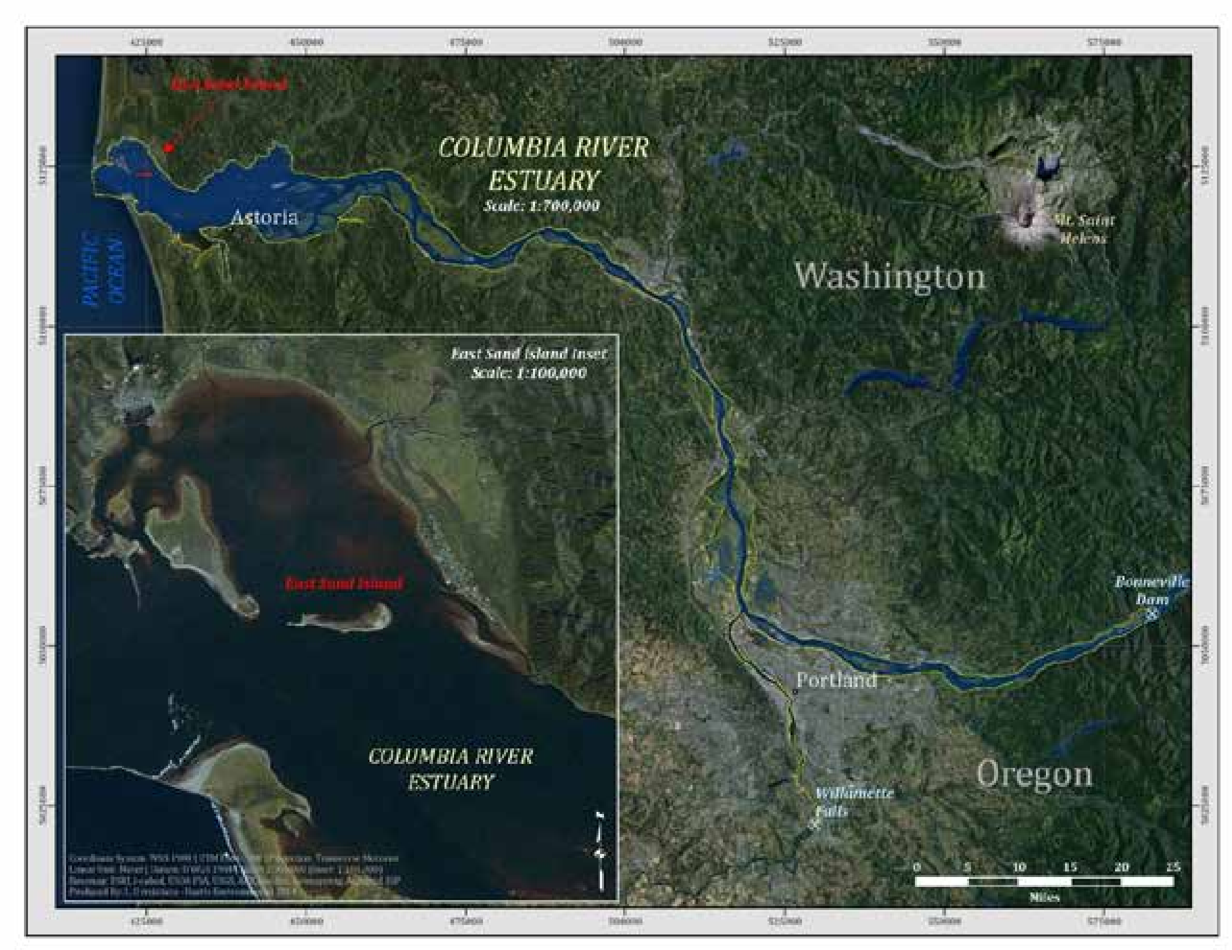


FIGURE 1-1. Map of the Columbia River Estuary, including East Sand Island.

The largest breeding colony of DCCOs in North America resides on East Sand Island (Roby et al. 2014). The DCCO peak breeding season (April-July) overlaps with the out-migration of millions of juvenile salmonid smolts, which are a prey source for DCCOs. DCCO nesting on East Sand Island was first documented in 1989, with fewer than 100 breeding pairs. Since then, the size of the colony has increased significantly; the highest count recorded was 14,900 breeding pairs in 2013 (Roby et al. 2014). During the last decade (2004-2013) the average breeding colony size has been 12,917 breeding pairs (Figure 1-2).

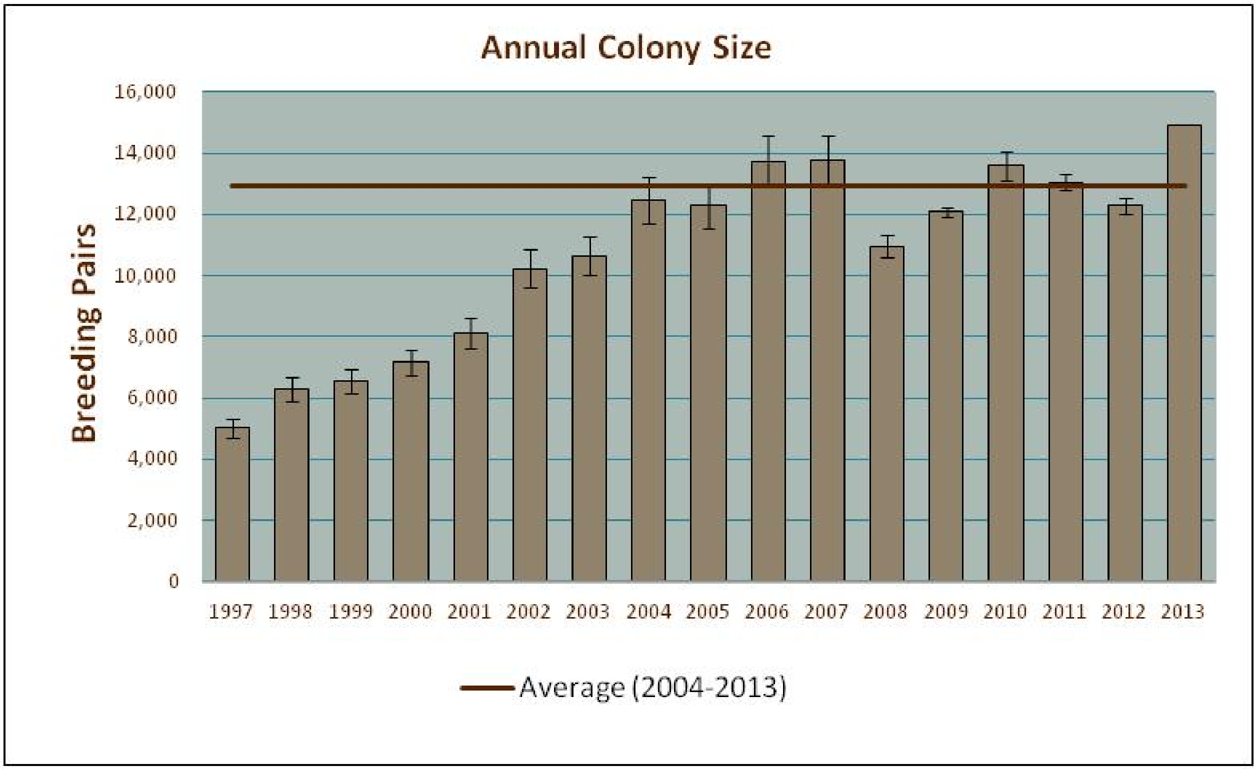


FIGURE 1-2. East Sand Island DCCO colony sizes, 1997-2013.

In addition to DCCOs, a variety of waterbirds use East Sand Island for roosting and nesting. The largest known breeding colony of Caspian terns (*Hydroprogne caspia*) in the world is on the eastern portion of the island. Glaucous-winged/western gulls (*Larus glaucescens/occidentalis*) are present throughout the island. A small colony of ring-billed gulls (*L. delawarensis*) nests near the tern colony on the eastern shoreline. Brandt's cormorants (*P. penicillatus*) nest within the DCCO colony. East Sand Island is also the largest known post-breeding roost site in the region for California brown pelicans (*Pelecanus occidentalis)*. The island provides an important foraging and roosting site for shorebirds in the winter and during migration (see Chapter 3 for more information).

Because of the large numbers and diversity of other birds using East Sand Island, the island is recognized as an Important Bird Area by the American Bird Conservancy and the National Audubon Society (see Appendix G for a list of birds observed during 2013 nesting season). These designations are important to conservation planning efforts, but they do not afford additional legal protection to East Sand Island. With the exception of Caspian terns (USFWS 2005a), the Corps does not actively manage or maintain East Sand Island to support a minimum or specific colony size or abundance of various bird species, including DCCOs.

1.1.2 Columbia River Estuary

For the purposes of this document, the Columbia River Estuary is defined as the region on the Columbia River that is influenced by ocean tides. It extends upriver to Bonneville Dam on the Columbia River at River Mile (RM) 146 and to the Willamette Falls, south of Portland, at RM 26 on the Willamette River, a major tributary to the Columbia River. In total, the Columbia River Estuary is 172 miles. The Columbia River Estuary varies between 3 to 5 miles in width in the main channel of the Columbia River and forms the border between Washington and Oregon.

The Columbia River Estuary is critical to the development of juvenile salmonids, providing essential rearing habitat and a migratory corridor for the various salmonid species and life history stages (Fresh et al. 2005). The Columbia River Estuary, from the mouth to RM 60, is also designated as a site of regional importance to shorebirds by the Western Hemispheric Shorebird Reserve Network. The USFWS Pacific Region Seabird Conservation Plan (USFWS 2005b) identifies the Columbia River Estuary as an important nesting and foraging area for terns, cormorants, and gulls (See Section 2.6 for more information on consistency with regional plans).

1.1.3 Double-crested Cormorants and the Migratory Bird Treaty Act

DCCOs are native to North America, and their range extends across much of the continent (USFWS 2003). There are five recognized DCCO subspecies in North America (Wires et al. 2001; USFWS 2003). The western population of DCCOs includes all breeding colonies within British Columbia, Washington, Oregon, Idaho, California, Nevada, Utah, Arizona, and the portions of Montana, Wyoming, Colorado, and New Mexico that lie west of the Continental Divide (Adkins et al. in press). The western population of DCCOs is a management population within the Pacific Flyway (Pacific Flyway Council 2012).

The estimated size of the western population of DCCOs ca. 2009 is approximately 31,200 breeding pairs (Adkins et al., in press). From 1987–1992 to ca. 2009, the number of DCCO breeding pairs estimated within British Columbia, Washington, Oregon, and California increased by approximately 72 percent (i.e., 3 percent per year), or 12,000 breeding pairs, and large-scale distributional changes occurred (Adkins et al., in press; Pacific Flyway Council 2012). The coastal states and provinces account for greater than 90 percent of the western population of DCCOs, with the majority of DCCOs breeding along the Pacific Coast (67 percent; Adkins et al., in press). Growth of the western population of DCCOs is largely attributed to the increase in size of the DCCO breeding colony at East Sand Island, which accounted for 39 percent of the western population of DCCOs during 2008–2010 (Adkins et al., in press). The DCCO increase at East Sand

Island likely initially resulted from immigration from other breeding colonies, as colony declines were documented in southern Alaska, British Columbia, Washington, and California (Carter et al. 1995; Hatch and Weseloh 1999; Moul and Gebauer 2002; Wires et al. 2001; Anderson et al. 2004b; Wires and Cuthbert 2006; Pacific Flyway Council 2012). Outside of East Sand Island, growth of the western population of DCCOs in other areas has been relatively static over the past two decades, with some isolated areas of limited DCCO increase (e.g., Idaho, Montana, Arizona) and areas of decline or concern for continued decline (e.g., Salton Sea, California) (Adkins et al., in press, Pacific Flyway Council 2012).

The Migratory Bird Treaty Act (MBTA) is the implementing legislation for treaties between the U.S. and four neighboring countries (Canada, Mexico, Russia, and Japan) for the protection of migratory birds. In 1972, DCCOs were added to the list of bird species afforded protection under the MBTA. The U.S. Fish and Wildlife Service (USFWS) has statutory authority and responsibility for enforcing the MBTA. Relevant regulations are found at 50 CFR Parts 10, 20, and 21. In 50 CFR 21.11, it states that "[n]o person may take, possess, import, export, transport, sell, purchase, barter, or offer for sale, purchase, or barter, any migratory bird, or the parts, nests, or eggs of such bird except as may be permitted under the terms of a valid permit issued pursuant to the provisions of [these regulations]." Take is defined as "to pursue, hunt, shoot, wound, kill, trap, capture, or collect, or the attempt to pursue, hunt, shoot, wound, kill, trap, capture, or collect" (50 CFR 10.12). 50 CFR 21.41-21.54 allow for take of migratory birds under certain conditions to minimize depredation.

1.1.4 Columbia River Basin Salmonids and the Endangered Species Act

Pacific salmon and steelhead are *salmonids*, of the scientific family *Salmonidae*. They are anadromous fish, which means they migrate up rivers from the ocean to breed in fresh water. They are in the scientific genus *Oncorhynchus*, which includes sockeye, chum, Chinook and coho salmon, and steelhead trout. These are the five species, referred to in this document as the Columbia River Basin salmonids, which use the Columbia River and its tributaries in their life cycles. They are listed under the Endangered Species Act (ESA) and migrate through the Columbia River Estuary to the Pacific Ocean.

Within the five species, there are thirteen different groupings, referred to as Evolutionarily Significant Units (ESUs) or Distinct Population Segments (DPSs), specifically listed under the ESA. ESU designations are used for the four species of Pacific salmon and DPS designations are used for steelhead in the Columbia River Basin. The definition of an ESU and DPS is essentially the same: a population that is substantially reproductively isolated from other units within the species and represents an important component of the evolutionary legacy of the species. The

USFWS and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NOAA Fisheries) issued a joint policy describing DPSs in Policy Regarding the Recognition of Distinct Vertebrate Population Segments Under the Endangered Species Act (61 CFR 4722 [1996]).

Under the ESA, a species is considered endangered if it is in danger of extinction throughout all or a significant portion of its range. A species is considered threatened if it is likely to become endangered in the future. The listing of a species under the ESA as endangered or threatened makes it illegal to "take" (harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, collect, or attempt to do these things). NOAA Fisheries manages marine and anadromous species, such as salmon and steelhead. It is federal policy that all federal agencies seek to conserve threatened and endangered species and utilize their authorities in furtherance of the purposes of the ESA (ESA Section 2(c)). The Columbia River Basin salmonids were first ESA-listed in the 1990s (Table 1-1).

TABLE 1-1. ESA-listed Columbia River Basin Salmonids.

Species, Evolutionarily Significant Unit (ESU) or Distinct Population Segment (DPS)*	Status
CHINOOK	
Lower Columbia River	Threatened
Upper Columbia River Spring-run	Endangered
Upper Willamette River	Threatened
Snake River Spring/Summer-run	Threatened
Snake River Fall-run	Threatened
COHO	
Lower Columbia River	Threatened
CHUM	
Columbia River	Threatened
SOCKEYE	
Snake River	Endangered
STEELHEAD	
Upper Columbia River	Threatened
Middle Columbia River	Threatened
Lower Columbia River	Threatened
Snake River	Threatened
Upper Willamette River	Threatened

Endangered Species Act Listing Policy for Hatchery-raised Fish

NOAA Fisheries 1993 interim policy on hatchery-raised Columbia River Basin salmonids stated that hatchery-origin fish should be listed only if they are essential to the conservation of the species. In 2001, however, the U.S. District Court in Oregon ruled that any hatchery-origin component that is part of a listed ESU must also be listed under the ESA (*Alsea Valley Alliance v. National Marine Fisheries Service*, 161 F. Supp. 2d 1154). NOAA Fisheries subsequently modified its hatchery policy to conform to this ruling, and the revised hatchery listing policy provides for the listing of a population that is found to be part of the ESU, regardless of whether it is of natural origin or hatchery-raised. The revised policy was upheld in 2009 by the 9th Circuit in *Trout Unlimited v. Lohn*, 559 F3d 946 (NOAA 2010). There are more than fifty hatchery facilities for Columbia River Basin salmonids operated by federal and state agencies, tribes, and private interests. These hatchery facilities support over 100 hatchery programs, which help increase harvest and conserve populations of the Columbia River Basin salmonids (NOAA 2010). Throughout this document, all references to Columbia River Basin salmonids include both hatchery-raised and natural-origin (wild) fish.

1.1.5 Federal Columbia River Power System Biological Opinion

The Corps operates and maintains several hydropower dams on the Columbia and Upper Snake Rivers, referred to together as the Federal Columbia River Power System (FCRPS). Because the dams adversely affect salmonids and their habitat, the Corps, along with Bonneville Power Administration and the Bureau of Reclamation, formally consults with NOAA Fisheries to ensure their actions are not likely to jeopardize the continued existence of ESA-listed Columbia River Basin salmonids or adversely modify their critical habitat.

In May 2008, NOAA Fisheries issued a 10-year Biological Opinion, which concluded that, through implementation of the recommended Reasonable and Prudent Alternative (RPA) actions, the operation of the FCRPS would not likely jeopardize the federally-listed Columbia River Basin salmonids affected by the system (NOAA 2008). The RPA actions to be implemented from the 2008 Biological Opinion include improving fish passage at dams, managing river flow, improving tributary and estuary habitat, reforming hatchery practices, and controlling predators that prey on juvenile salmonids.

In 2008 and subsequent years, the Federal Action Agencies to the 2008 FCRPS Biological Opinion reached agreements with several Columbia Basin tribes and states. Each Columbia Basin Fish Accords Memorandum of Agreement secured funding to implement a variety of projects throughout the Columbia River Basin, including restoration of salmon and steelhead habitat. These agreements established a partnership among the Federal Action Agencies, six Northwest tribes, one inter-tribal organization, and three states. The agreements secured federal funding of over $900 million to implement many of the Biological Opinion's RPA actions through the 2018 expiration of the Biological Opinion. The Corps manages the Columbia River Fish Mitigation Program with yearly expenditures of over $100 million for research and general construction projects to improve habitat, passage, and survival of Columbia River Basin salmonids.

On May 20, 2010, NOAA Fisheries completed a 2010 Supplemental Biological Opinion, incorporating an Adaptive Management Implementation Plan into the 2008 Biological Opinion (NOAA 2010). Predation of juvenile salmonids by DCCOs is listed as one of the factors potentially limiting the recovery of Lower Columbia River Chinook, steelhead, and coho, and Upper Willamette River Chinook and coho (NOAA 2008). Two RPA actions from the 2008 FCRPS Biological Opinion specifically address management of DCCOs in the Columbia River Estuary:

- ***RPA- 46*** requires the development of a management plan for DCCOs in the Columbia River Estuary and implementation of warranted actions in the Estuary.
- ***RPA- 67*** requires the DCCO population in the Columbia River Estuary and the population's impact on out-migrating juvenile salmonids be monitored. RPA-67 also calls for the implementation of a management plan to decrease predation rates, if warranted.

In accordance with the August 2, 2011 U.S. District Court for the District of Oregon Order, the 2010 FCRPS Supplemental Biological Opinion was remanded to NOAA Fisheries. In response, NOAA Fisheries prepared a Supplemental Biological Opinion, which was finalized in January 2014 (NOAA 2014). RPA 46 was modified to read:

Modified RPA 46 Double-Crested Cormorant Predation Reduction

"The FCRPS Action Agencies will develop a cormorant management plan (including necessary monitoring and research) and implement warranted actions to reduce cormorant predation in the estuary to Base Period levels (no more than 5,380 to 5,939 nesting pairs on East Sand Island)" (NOAA 2014).

1.1.6 Research on Double-crested Cormorants in the Columbia River Estuary

The Corps has funded research to determine the potential effects of DCCO predation on juvenile salmonids and as a means to determine effective field methods that could be applied on East Sand Island for future management as well as to track movement of DCCOs to better quantify effects.

Colony Monitoring and Smolt Consumption

In 1997, the Corps began funded studies to monitor the size, productivity, and diet of DCCO colonies in the Columbia River Estuary. DCCOs were found to nest at several locations in the Columbia River Estuary during the course of this research (1997-2013), including the largest colony on East Sand Island and smaller colonies on a dredge material island (i.e., Rice Island at RM 21) and structures (i.e., Astoria-Megler Bridge and channel markers) located further upriver.

Diet composition studies revealed that DCCOs nesting in the upper estuary (on Rice Island and channel markers) were far more reliant on freshwater fish species, including salmonids, than DCCOs nesting closer to the river mouth on East Sand Island, which consumed a greater proportion of marine forage fish (Collis et al. 2002). Juvenile salmonids were three times more prevalent in the diet of DCCOs nesting in the upper estuary (45 percent of the identifiable biomass), as compared to DCCOs nesting on East Sand Island (15 percent; Collis et al. 2002). This study, along with data from subsequent diet studies at East Sand Island, revealed that the percentage of the diet that is salmonids for DCCOs varies both spatially and temporally (Roby et al. 2014), suggesting that the relative abundance and availability of forage fish in the Columbia River Estuary varies considerably both within and among years.

A bioenergetics model was developed to estimate the number of juvenile salmonids (by species) consumed annually by the large DCCO colony on East Sand Island. During 2003–2013, estimates of total annual smolt consumption by the East Sand Island DCCO colony have varied between 2.4 and 20.5 million smolts (mean = 11.0 million; Figure 1-3). Salmonid consumption by the East Sand Island DCCO colony peaks in early May, which coincides with the peak nesting season (Figure 1-4).

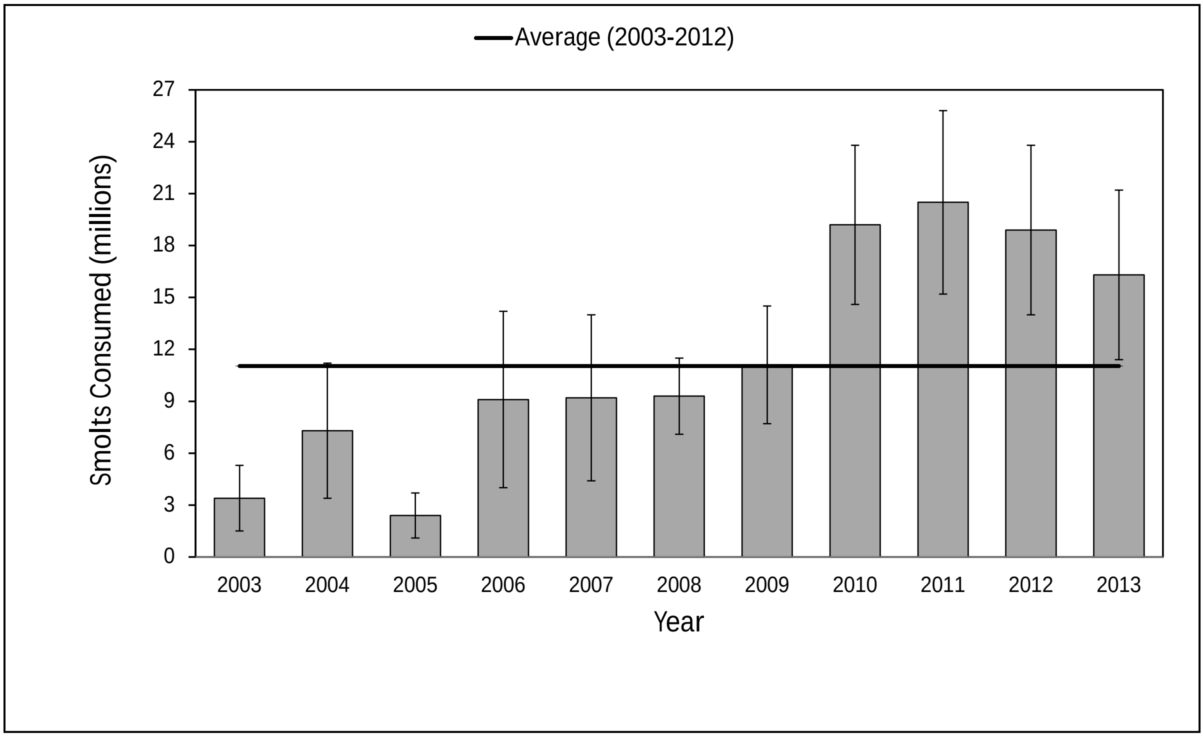


FIGURE 1-3. Estimated total annual consumption of juvenile salmonids by DCCOs on East Sand Island during the 2003–2013 breeding seasons.

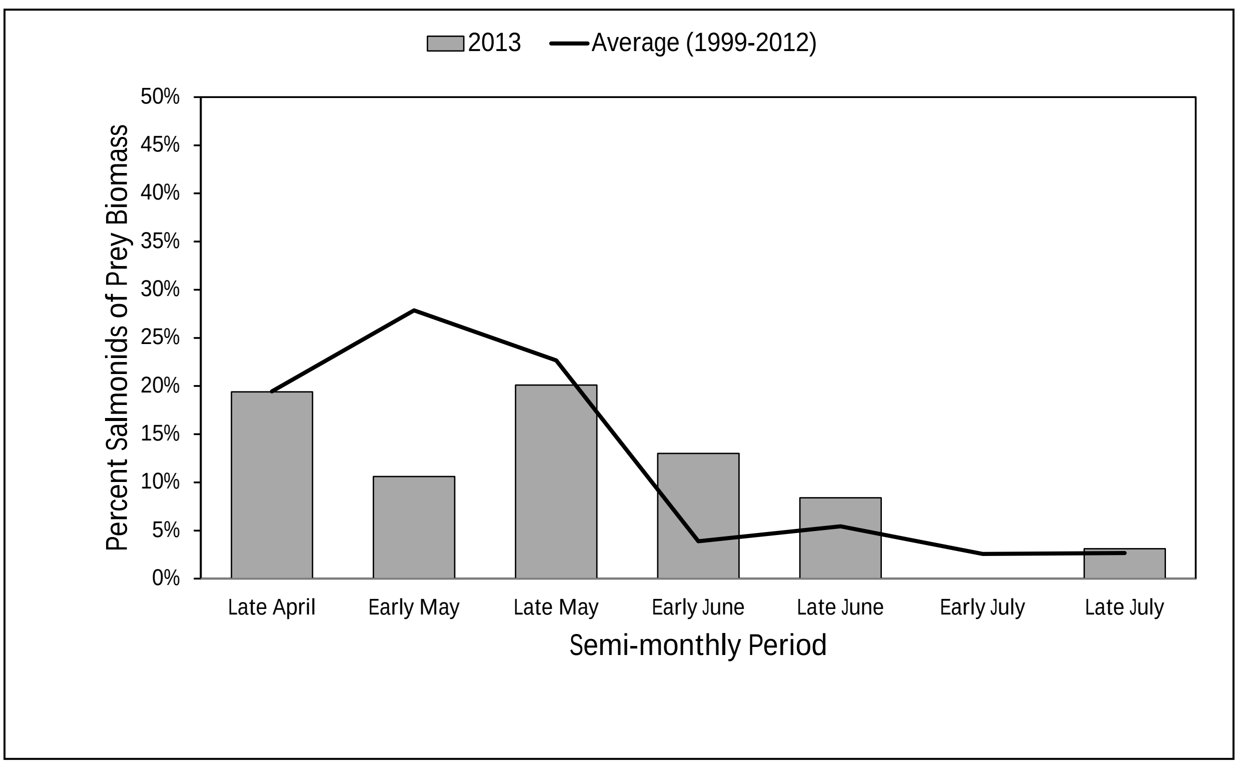


FIGURE 1-4. Seasonal proportion of juvenile salmonids in the diet of DCCOs nesting on East Sand Island during 1999-2013.

To assess impacts on salmonids from DCCO predation at the level of the ESU or DPS, PIT tags from smolts consumed by DCCOs were recovered on the East Sand Island colony following the breeding season. This allows for an estimate of DCCO predation rates (i.e., the proportion of juvenile salmonids available in the estuary and consumed by DCCOs). During 2004-2013, average annual predation rate estimates derived from PIT tag recoveries at the East Sand Island DCCO colony ranged from 6.2 to 7.6 percent for three steelhead DPSs, 1.7 to 4.4 percent for four Chinook ESUs, and 4.0 percent for the Snake River Sockeye ESU (only ESA-listed ESUs or DPS originating upstream from Bonneville Dam and Sullivan Dam on the Willamette River were evaluated; see Appendix C). Similar to smolt consumption estimates, DPS- and ESU-specific predation rate estimates were highly variable and differed by salmonid population and year.

Factors Influencing Predation

Factors driving the large inter-annual variation in predation impacts (consumption and predation rates) include, but are not limited to: environmental conditions as they affect the timing, abundance, and availability of forage fish in the estuary (e.g., river discharge, tidal volume, sea surface temperature, upwelling timing and strength), differences in DCCO abundance, nesting chronology, and nesting success, and large-scale climatic factors that influence both the prey and predator (e.g., El Niño Southern Oscillation, Pacific Decadal Oscillation, North Pacific Gyre Oscillation, Pacific Northwest Index). These factors will be considered when predicting and interpreting the success of DCCO management actions on East Sand Island within a given year and over the long-term.

Habitat Enhancement and Social Attraction

Social attraction techniques consist of setting up decoys and broadcasting audio playback of bird calls to encourage nesting. These techniques have been tested within and outside the Columbia River Estuary for several years as a possible method to redistribute the East Sand Island DCCO colony (Suzuki et al. 2012).

Social attraction within the Estuary — In 2004, social attraction was tested on portions of East Sand Island where no DCCOs had previously nested. Social attraction was successful in facilitating nesting of DCCOs in new areas on East Sand Island. During 2004–2008, social attraction was also employed on Miller Sands Spit and Rice Islands with limited success as a means to easily redistribute a large portion of the East Sand Island colony. Since 2009, there have been no documented DCCO nesting attempts at Miller Sands Spit or Rice Islands.

Social attraction outside the Estuary — During 2007–2012, social attraction techniques were used to encourage DCCOs to nest outside of the Columbia River Estuary at four known roosting sites in Oregon and California. Social attraction efforts were conducted during the breeding season at Fern Ridge in northwestern Oregon (2007–2009), at Summer Lake Wildlife Area in central Oregon (2010–2011), at Tule Lake National Wildlife Refuge in northeastern California (2011–2012), and at Malheur National Wildlife Refuge in southeastern Oregon (2012). There were no nesting attempts by DCCOs at any of these locations.

Non-lethal Dissuasion Studies

In 2008, the Corps began studies to investigate certain non-lethal methods to dissuade DCCOs from nesting in specific locations on East Sand Island. Methods tested to date include human disturbance (2008–2009 and 2011–2013), removal of nest structures prior to egg-laying (2011–2013), pond liners placed over nesting substrate (2009–2010), hazing using lasers (2008–2009), and reflective tape placed in nesting trees (BRNW 2013a). During 2011–2013, studies were initiated to test the use of privacy fences and targeted human disturbance prior to egg-laying to reduce the amount of available nesting habitat for DCCOs, which is approximately 16 acres on the western portion of the island (Figure 1-5).

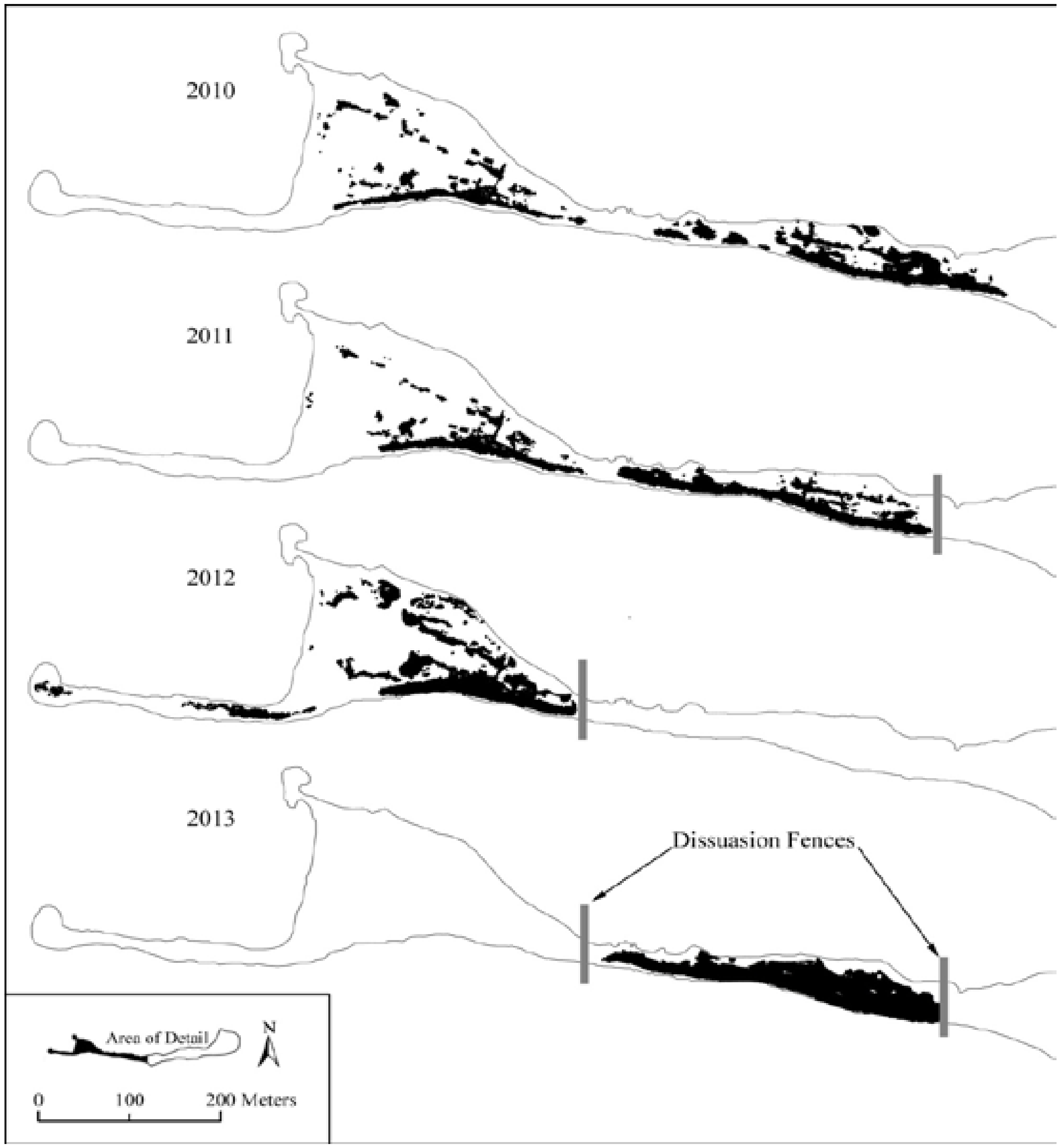


FIGURE 1-5. Distribution of DCCO nests on the west end of East Sand Island during 2010–2013 and placement of dissuasion fence.

The use of privacy fences and human disturbance in 2011-2013 was effective in deterring DCCOs from breeding within the designated nest dissuasion areas (Figure 1-6). These techniques reduced the available nesting habitat during the breeding season by approximately 6 percent in 2011, 31 percent in 2012, and 75 percent in 2013 (Roby et al. 2014; BRNW unpublished data). As part of these studies, breeding adult DCCOs were marked with VHF radios (n=60 [2011]; n=126 [2012]) or satellite transmitters (n=12 [2012]; n=83 [2013]) to provide information about where DCCOs moved during the dissuasion efforts. Despite these reductions in the amount of available nesting habitat, DCCOs nested successfully on East Sand Island in every year, and there was no appreciable change in colony size.

FIGURE 1-6. Photo of East Sand Island showing past DCCO dissuasion methods, July 2012 (Photo Credit: Corps).

After some off-colony dispersal immediately following tagging, most radio- and satellite-tagged DCCOs returned to roost or nest on or near East Sand Island in the same year that they were tagged and dissuaded from nesting. There was little evidence of permanent emigration from the Columbia River Estuary associated with nest dissuasion experiments during the 2011-2013 breeding seasons (Roby et al. 2014).

Although permanent emigration did not occur, initial, or near-term dispersal is considered indicative of where DCCOs could relocate if habitat was not available on East Sand Island. Locations of radio- and satellite-tagged DCCOs dissuaded from East Sand Island during the 2011-2013 breeding seasons consisted of four main areas: 1) Columbia River Estuary; 2) outer Washington coast (Willapa Bay and Grays Harbor); 3) Puget Sound; and 4) northern Salish Sea (San Juan Islands, Strait of Georgia, Vancouver, BC) (Roby et al. 2014). There were no confirmed detections of radio- or satellite-tagged DCCOs at inland sites east of the Dalles Dam or coastal sites south of Cannon Beach, Oregon. These areas do not necessarily overlap with active or historic colonies but represent areas that DCCO visited when hazed from East Sand Island.

Post-Breeding Dispersal Studies

During 2008–2009, 51 DCCOs on East Sand Island were marked with satellite tags to determine their movement after the nesting season (post-breeding dispersal) and the connectivity of birds breeding at East Sand Island to other areas. DCCOs satellite-tagged on East Sand Island had the greatest connectivity with three estuarine and inner coastal regions to the north (i.e., Willapa

Bay, Grays Harbor, and the Salish Sea) and the Western Columbia Basin (Courtot et al. 2012). Although DCCOs were detected from southern British Columbia to the Colorado River delta in northern Mexico, and as far east as western Nevada, frequency of DCCO use within this range decreased dramatically with distance from East Sand Island. There was little connectivity to colonies east of the Cascade-Sierra Nevada Mountains or along the coasts of Oregon, southern California, or Mexico (Courtot et al. 2012).

DCCO band re-sighting data from birds banded at East Sand Island and elsewhere in the Columbia River Estuary support the radio- and satellite-tagging results of minimal DCCO movement east of the Cascade-Sierra Nevada Mountains and primary connectivity to northern coastal areas in Washington and British Columbia (Clark et al. 2006; Roby et al. 2013). During 1995–2000, 3,635 DCCO fledglings from East Sand Island and Rice Island were banded; less than 4 percent of all band recoveries were east of the Cascade-Sierra Nevada Mountains, and 63 percent of band recoveries were from coastal Washington and British Columbia (Clark et al. 2006). During 2008–2013, 1,961 DCCOs (816 adults and 1,145 juveniles) were marked with field-readable color bands. As of February 2014, approximately 55 percent of re-sighting records and dead recoveries (36 of 65) were in coastal Washington and British Columbia (Roby et al. 2013, 2014). The remaining re-sighting records and dead recoveries were in coastal Oregon (6 percent), interior Washington, the Lower Columbia and Willamette Rivers (17 percent), and California (the entire state; 22 percent; Roby et al. 2013, 2014).

1.2 Purpose of and Need for Action

The purpose of the proposed action is to reduce DCCO predation of juvenile salmonids in the Columbia River Estuary to levels identified in the environmental baseline (base period) of the 2008/2010 FCRPS Biological Opinion (NOAA 2008, 2010). To meet this purpose, the targets identified in the revised RPA 46 for juvenile salmonid survival and associated DCCO colony size (5,380 to 5,939 breeding pairs on East Sand Island) based on NOAA Fisheries analysis are being used for management objectives (NOAA 2014). In meeting this purpose, impacts to species not targeted for management would be minimized to the extent possible.

Need

The 2008/2010 FCRPS Biological Opinion did not completely address the full impact of the rapidly increasing DCCO population in the Columbia River Estuary on salmonid survival. To address this, NOAA Fisheries conducted a "survival gap" analysis looking at the difference in DCCO predation on steelhead, yearling Chinook, and sockeye between the "base period" of 1983-2002 and the "current period" of 2003–2009 (Appendix D). This analysis was included in the 2014 Supplemental FCRPS Biological Opinion (see section 1.1.5).

During 1998–2012, DCCO consumption rates of juvenile steelhead, yearling Chinook, and juvenile sockeye were estimated to be 6.7 percent, 2.7 percent, and 1.3 percent, respectively (Appendix D). Since steelhead appear to be more susceptible to DCCO predation (compared to other salmonid species and in the context of the FCRPS Biological Opinion), they are used to describe survival improvement targets that could be achieved through DCCO management. Actions taken to improve juvenile steelhead survival would additionally benefit other juvenile salmonids. NOAA Fisheries estimated a 97.1 percent survival rate (i.e., 2.9% DCCO consumption rate) for juvenile steelhead during the "base period" compared to 93.5 percent (i.e., 6.5% DCCO consumption rate) in the "current period," a base to current gap of 3.6 percent (Appendix D; Figure 1-7). NOAA Fisheries then determined that a reduced DCCO breeding population of 5,380 to 5,939 breeding pairs on East Sand Island would restore juvenile steelhead survival to the environmental baseline or "base period" levels.

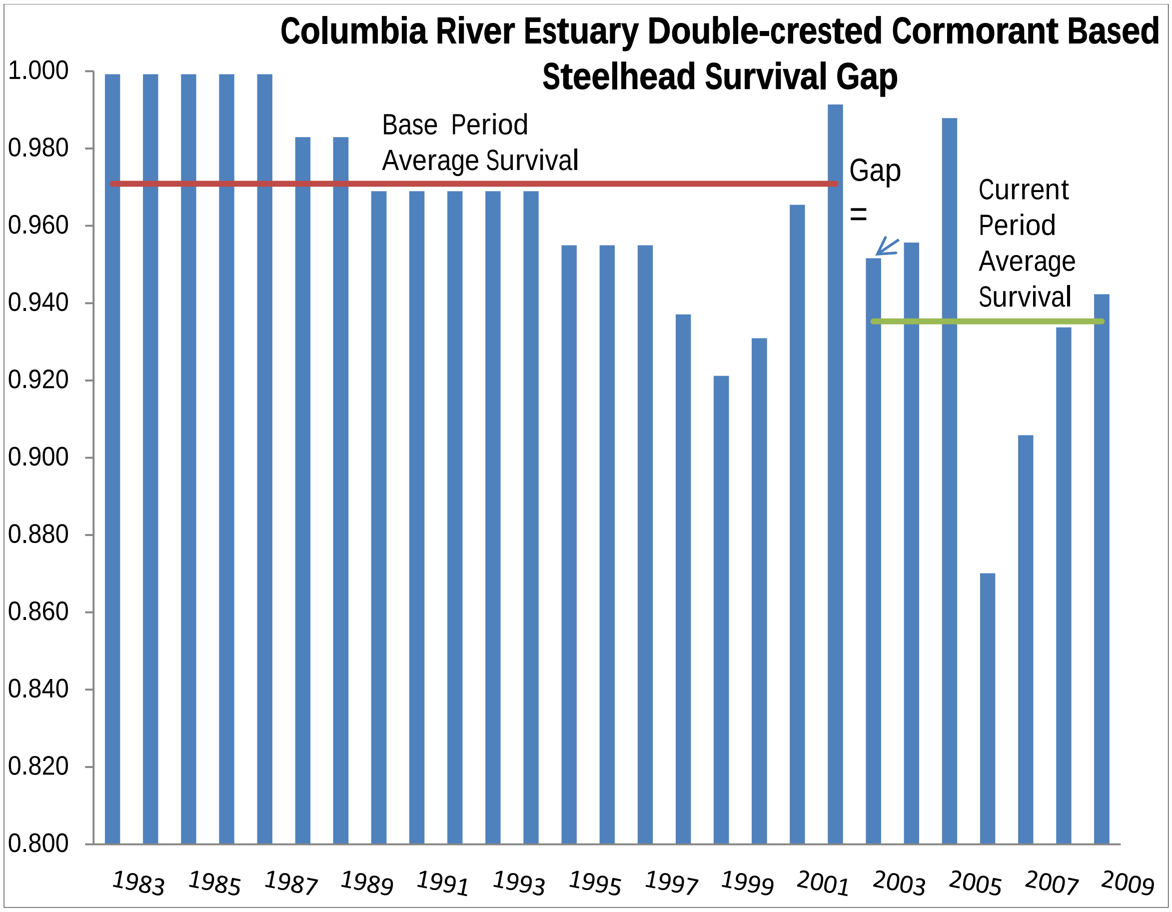


FIGURE 1-7. Estimated annual juvenile steelhead survival and average survival estimates during the "base period" (1983-2002) and "current period" (2003-2009). Annual survival estimates were derived from DCCO consumption data and estimated numbers of available juvenile salmonids and DCCOs in the Columbia River Estuary.

In the context of other FCRPS efforts and survival requirements, DCCO predation can be a significant source of mortality for some Columbia River ESU or DPS salmonid groups. For example, dam passage survival of steelhead and spring Chinook salmon at Bonneville Dam is required to be 96 percent (no more than 4 percent mortality). In 2011, estimated juvenile steelhead survival was higher than this threshold, at 97.5 percent (2.5 percent mortality). This level of mortality is approximately 2.7 times less than mortality from East Sand Island DCCO predation (6.7 percent; NOAA 2014).

Compared to the NOAA Fisheries analysis, other studies and analyses have documented much higher mortality rates from DCCO predation on certain Columbia River ESU or DPS salmonid groups during a given year (e.g., 15 percent, Zamon et al. 2013; 13 percent, Lyons et al. 2014; and 17 percent, Appendix C). Thus, for some ESU or DPS salmonid groups, DCCO predation impacts, on average, can be similar to or exceed the mortality experienced at a hydro-system facility in the FCRPS, and, in some years, can be 3 to 4 times higher. Furthermore, McMichael et al. (2010) found that the highest rates of juvenile salmonid mortality occurred in the downstream-most 31 miles of the Columbia River Estuary. Harnish et al. (2012) also concluded that mortality was highest for juvenile steelhead and Chinook salmon between RM 22 and RM 4, suggesting this was due to the proximity of large nesting colonies of piscivorous birds on East Sand Island. Based on the documented adverse impacts of DCCO predation of juvenile salmonids in the Columbia River Estuary and the regional commitment to improve salmonid survival, there is a need to reduce DCCO predation to the levels specified in the FCRPS Biological Opinion.

There is also a need to develop a management strategy that achieves reduction in predation throughout the Columbia River Estuary and minimizes impacts where feasible to other species. As previously stated, East Sand Island and the Columbia River Estuary are important bird areas due to the large number of birds using the island and estuary for nesting, roosting, and foraging. Dispersal of DCCOs from East Sand Island also has the potential to cause greater impact to ESA-listed juvenile salmonids if they move to upriver sites along the lower Columbia and Snake Rivers (Collis et al. 2002) or to other areas in the affected environment where ESA-listed fish exist.

1.3 Lead and Cooperating Agencies

In response to the 2008 FCRPS Biological Opinion (NOAA 2008), an interagency working group formed in 2010 to address the effects of DCCO predation on the recovery of ESA-listed Columbia River Basin salmonids. The working group developed conceptual alternatives (based on percent reduction of colony sizes) and prepared a status assessment of DCCO, which was used in the development of the EIS. A Notice of Intent announcing the Corps' preparation of an EIS was published in the Federal Register on July 19, 2012 (Fed. Reg., Volume 77, No 139, p. 42487). All of the agencies and tribes involved in the working group received written requests by the Corps to participate as cooperating agencies in the development of the EIS. These requests were sent August 1, 2012. The following is a list of the agencies that accepted the invitation and a description of their roles in the development of the EIS.

U.S. Army Corps of Engineers (Corps)

The Corps' Civil Works programs provide engineering and construction services for water resource development and management, flood risk management, emergency response, navigation, recreation, infrastructure (such as multiple-purpose hydroelectric power projects), and environmental restoration and stewardship. The Water Resources Development Acts (WRDA) are passed by Congress to provide for the conservation and development of water and related resources, to authorize the Secretary of the Army to construct various projects for improvements to rivers and harbors of the United States, and for other purposes related to USACE missions.

The Corps is the lead agency for the EIS under NEPA, the federal land manager of East Sand Island, and an action agency with responsibility under ESA for FCRPS consultation. Authority for the Corps to implement actions to manage DCCOs comes from the WRDA 1996 Subsection "511(c) which authorized management of avian predators on Corps' dredged material islands to reduce predation of endangered salmonids." Funding comes from the Columbia River Fish Mitigation appropriations.

U.S. Fish and Wildlife Service (USFWS)

The mission of the USFWS is working with others to conserve, protect, and enhance fish, wildlife, and plants and their habitats for the continuing benefit of the American people. The USFWS has statutory authority and responsibility for enforcing the MBTA (16 U.S.C. 703–711). Under the MBTA, the USFWS implements conventions between the United States and four neighboring countries (Canada, Mexico, Russia, and Japan) for the protection of our shared migratory birds, and maintains the list of species protected under the MBTA (50 CFR 10.13).

USFWS responsibilities include the conservation and management of DCCOs, which are included on the list of protected migratory birds.

The role of USFWS in this EIS is to provide technical assistance in developing alternatives to minimize impacts to DCCO and other migratory birds. The USFWS developed the population model (Appendix E-1) to assess the effects of different levels of individual and egg take on the East Sand Island DCCO colony and the western population of DCCOs. The USFWS will use this EIS to support their permit decision-making upon receipt of an application for a federal Migratory Bird Permit (50 CFR 21) from the Corps for the take of migratory bird adults, eggs, or both, depending on which alternative the Corps makes a decision on.

U.S. Department of Agriculture - Wildlife Services (USDA-WS)

The mission of the USDA-WS program is "to provide Federal leadership and expertise to resolve wildlife conflicts to allow people and wildlife to coexist." The USDA-WS is authorized by law to protect American agriculture and other resources from damage associated with wildlife. They provide assistance to agencies, organizations, and individuals in resolving wildlife damage problems on both public and private lands. When responding to requests for assistance, USDA-WS may provide technical assistance (e.g., advice, information, or equipment), direct control assistance, and research assistance. Technical and direct control assistance may involve the use of either non-lethal, lethal, or a combination of the two methods. The primary statutory authority for the USDA-WS program is the Act of March 2, 1931 (46 Stat. 1468; 7 U.S.C. 426-426b) as amended in December 22, 1987 (101 Stat. 1329-331; 7 U.S.C. 426c).

The role of USDA-WS in this EIS process is to provide their subject matter expertise in developing alternatives and identifying methods appropriate to proposed DCCO management. As the Corps would request technical assistance from USDA-WS to implement the preferred alternative they would need to, as a federal agency, ensure that action is compliant with NEPA and other applicable federal and state laws. This EIS serves as the NEPA compliance for USDA-WS to directly assist the Corps in management.

Oregon Department of Fish and Wildlife (ODFW)

ODFW's mission is to protect and enhance Oregon's fish and wildlife and their habitats for the use and enjoyment of present and future generations. ODFW regulates fishing in the state and operates hatcheries to improve salmonid runs in the Columbia River and its tributaries. The role of ODFW in this EIS process is to ensure protected resources, such as sensitive fish and wildlife populations, are considered when alternatives are being evaluated. ODFW identified areas of specific management concern identified in Chapter 3 and provided information on current DCCO hazing efforts in coastal estuaries.

Washington Department of Fish and Wildlife (WDFW)

The WDFW mission is to preserve, protect, and perpetuate fish, wildlife, and ecosystems, while providing sustainable fish and wildlife recreational and commercial opportunities. WDFW regulates fishing in the state and operates hatcheries to improve salmonid runs in the Columbia River and its tributaries. The role of WDFW in this EIS process is to ensure protected resources, such as sensitive fish and wildlife populations, are considered when alternatives are being evaluated. WDFW identified areas of specific management concern identified in Chapter 3.

1.4 Scoping

Scoping is a process intended to inform the public early on when a federal agency is considering taking an action that is likely to have significant impacts on the environment. This process is also used to inform the federal agency, through stakeholder and public involvement, of important issues to consider in making their decision on whether or how to implement the proposed action. A public notice announcing the scoping process, public meetings, and website for the EIS was sent on October 25, 2012. Over 150 interested parties, non-governmental organizations, other federal, state, and local agencies, and other individuals who had previously contacted the Corps about past research efforts on East Sand Island were notified. The notice announced that lethal and non-lethal methods were being considered to reduce the colony size. A press release to the local media was issued on October 29, 2012, announcing the scoping process and public meetings. The deadline for submitting comments was set for December 21, 2012. Oregon Public Broadcasting, the Daily Astorian, the Columbia Basin Bulletin, and the Chinook Observer carried stories on the public meetings. Social media releases were also used to announce the public meetings and proposed EIS.

Public Meetings

Three open house public meetings were held to discuss the Corps' proposal for the EIS. The meeting locations were Olympia, Washington (November 8, 2012), Portland, Oregon (November 13, 2012), and Astoria, Oregon (November 15, 2012). One woman, who is a member of the local chapter of the Audubon Society, attended the meeting in Olympia. Two environmental consultants, who are local sport fishermen, attended the meeting in Portland. Also in attendance was a liaison to USDA-WS, who is working with the Oregon Department of Transportation (ODOT) on a multi-year maintenance project on the Astoria-Megler Bridge. This individual expressed concerns about hazed birds coming to the bridge to forage or nest, and the effects that might have for completing bridge maintenance on schedule and within budget. Approximately thirty people attended the meeting in Astoria. Commercial fishermen were very concerned about diminished catches and economic losses, which they attributed to both birds consuming juvenile salmonids and the Oregon Governor's plan to limit gill netting on the Columbia River. Many were confused as to why, in other parts of the country, the USFWS allows many states to cull DCCOs, but not in Washington or Oregon. Others stated that, in recent years, the increased DCCO population has created a cleanliness problem at homes and businesses, due to large amounts of guano. A group of wildlife representatives were vocal about the negative effects that hazing DCCOs would have on California brown pelicans on East Sand Island and the lack of potential habitat for DCCOs if they were forced to leave.

1.4.1 Comments from Scoping

The following general themes, reflecting concerns of the public, emerged from verbal comments made during public meetings and from twenty-two written comments received. This information was included in a newsletter that was sent to the DCCO EIS email distribution list (nearly 200 contacts) and was posted on the project website: (http://www.nwp.usace.army.mil/Missions/Currentprojects/CormorantEIS.aspx). After the general comment theme below, a reference to the section in this document where the topic is addressed in greater detail is included. Several individuals commented with proposed potential solutions to reduce the level of predation. These suggestions are addressed in Chapter 2.

Scope of EIS: Focus more on birds, focus more on fish (ESA-listed and non-listed); have a balanced scientific approach; expand the geographic scope beyond Bonneville Dam; approach management more cautiously, approach it more aggressively; disclose the relationship of the EIS to other management plans. *(Section 1.2, Section 2.6)*

Root Causes: Address the root causes (dams, flow management, hatchery management, etc.) that affect juvenile survival and do not just react to a symptom caused by an artificially created environment. *(Section 2.3)*

Dispersal: Consider and mitigate the potential impacts DCCOs may have on other public resources (bridges, rooftops, other protected fish species, etc.) if they are displaced from East Sand Island. There were also some concerns about health and safety from DCCO guano. *(Sections 4.2 and 4.3)*

Commercial and Recreational Fishing: Address the loss of income and jobs in fisheries due to the predation impacts. *(Section 4.3)*

Economics: Consider the massive investment of millions of public dollars spent over the years and throughout the Columbia Basin to recover salmon, and how that may be offset from DCCO predation impacts. *(Section 1.2, Section 4.3)*

Tribal Treaty Rights: Address the need for the federal government to honor and protect Columbia River tribal treaty and fishing rights. Harvests of non-listed salmonid runs are critical to ensure federally-protected fishing rights are preserved. *(Section 3.3 and 4.3)*

Management Standards: Address the perception that there are different standards for management of DCCOs throughout the country, and provide a rationale for the requirement to implement non-lethal methods before lethal take is considered; incorporate an analysis of the ethics of using lethal take, if it is proposed. *(Section 2.4, 2.7 and Section 4.6)*

Wildlife on East Sand Island: Consider how actions to manage DCCOs would impact their regional population and other wildlife on the island, such as California brown pelicans and Brandt's cormorants. *(Section 4.2.3)*

Climate Change: Consider the effects climate change may have on Columbia River flows and the possibility that higher springtime flows may affect availability of other prey sources for DCCOs, thereby influencing predation rates on juvenile salmonids. *(Chapter 4)*

Compensatory Mortality: Address the uncertainty over whether juvenile salmonids would die from other sources of mortality, specifically in the ocean, if they are not consumed by DCCOs. *(Section 4.6)*

Scientific Methodology: Questions came up about the quality of the bioenergetics and consumption studies as they relate to the findings of the annual predation impacts. There is perception that management of DCCO and lethal take may not be warranted by the research findings. *(Section 1.2, Section 4.2.5)*

1.4.2 Other NEPA Documents Related to this EIS

The following NEPA documents are being prepared, or have recently been prepared and are related to this EIS. See Cumulative Effect (Section 4.5) for additional information on the combined effects of some of these actions.

USFWS

In 2003, the USFWS published regulations establishing a Public Resource Depredation Order to facilitate the protection of public resources from DCCOs in 24 eastern states and expanded provisions of an existing Aquaculture Depredation Order in 13 eastern states (USFWS 2003). Western states were not included in either depredation order because depredation concerns and documented DCCO impacts were not as pervasive as those of Interior and Eastern DCCO populations, and DCCO conflicts could be addressed adequately through other existing regulatory procedures (i.e., depredation permits).

In 2009, the USFWS approved a five-year extension of the regulations under an Environmental Assessment. These regulations will expire on June 30, 2014. On November 8, 2011, a Notice in the Federal Register was published seeking comments to guide the preparation of an additional NEPA document to revise or extend existing regulations. The comment period closed on April 6, 2012. Comments were received requesting the addition of the states of Oregon, California, Idaho, and Wyoming under the Public Resources Depredation Order. On May 28, 2014, the USFWS published, with supporting NEPA, a five-year extension of the existing Depredation Orders, until June 30, 2019.

Chapter 2 Alternatives

2.1 Introduction

This chapter describes the range of alternatives that were developed to meet the stated purpose and need. Each alternative contains a set of actions, monitoring efforts and potential adaptive responses that make up a management plan. A description of each alternative is provided as well as a summary table for comparing alternatives that are carried forward for further study. Finally, this chapter explains why other alternatives were dismissed from detailed study and identifies mitigation measures, required permits, and the relationship of this EIS to other policies and plans.

2.1.1 How Alternatives Were Developed

In response to the 2008 FCRPS Biological Opinion, an interagency working group met in 2010 to develop a draft management plan and conceptual alternatives to reduce the DCCO colony on East Sand Island by various percentages using non-lethal, lethal, and a combination of the two methods. The draft management plan provided the basis for public scoping meetings and public input and was summarized on the project website. Several alternatives were suggested during public scoping. Some alternatives were considered, but were eliminated from further evaluation with the rationale provided later in section 2.3.

Some ideas generated during public scoping were integrated into the proposed alternatives. Cooperating agencies identified priority issues and identified areas of specific management concern that were also integrated into the proposed alternatives; specifically ODFW and WDFW raised concerns over dispersal of DCCOs and possible conflicts with fish of conservation concern in their respective states (see Chapter 3 section 3.2.7). The specific management objective for reducing predation impacts (i.e., target colony size) was identified in the 2014 Supplemental FCRPS Biological Opinion (NOAA 2014).

2.1.2 Description of Wildlife Management Techniques Considered in this EIS

There are two general categories of DCCO management techniques: non-lethal and lethal. Non-lethal actions do not constitute “take” as defined by the MBTA, whereas lethal actions do.

However, implementation of non-lethal techniques, in certain circumstances which would result in loss of eggs or chicks, can result in "take". Available non-lethal and lethal techniques are described below. The primary techniques proposed for use in the alternatives are noted in Chapter 2. Techniques were taken from relevant literature (USDA-WS 1997; USFWS 2003; Pacific Flyway Council 2012) and developed in coordination with the cooperating agencies and input from public scoping.

Non-lethal Methods

Hazing — any activity to discourage nesting, roosting, and foraging behavior, such as: using visual and noise deterrents, modifying habitat, using boats or other similar equipment, or any other dispersal techniques.

Visual deterrents — human or animal (e.g., dog) disturbance, any moving or stationary object, or any object that emits deterring stimuli, such as: mylar or reflective tape, rope, other material between or on objects, hand-held or positioned lasers or lights, water cannons, eagle kites or other kites, effigies, scarecrows, or decoys of predators or humans.

Noise deterrents — any noise or noise producing object, such as: pyrotechnics, screamer shells, bird bombs, 12 gauge cracker shells, propane cannons, live ammunition, whistling projectiles, exploding projectiles, bird bangers, flash and detonation cartridges, sirens, or distress calls.

Habitat modification — any measure taken to change the way habitat could be used to make it unsuitable for that use, such as: creating temporary or permanent obstruction or exclusion devices and barriers (e.g., nets, cones, fences, wire devices, floating rope, line, screen, tarps, pond liners, etc.), or causing temporary or permanent physical changes to the topography or landscape (e.g., creating berms, increasing vegetative cover, removing trees, flooding areas, etc.). Habitat modification also includes removing, tearing down, or scattering nest materials or constructed nests that do not contain eggs.

Lethal Methods

Egg addling/destruction/oiling — destroying the embryo in an egg prior to hatching by shaking or other methods, breaking eggs by physical means, spraying eggs with food grade oil to suppress embryo development, or doing any other action, such as shooting an individual incubating an active nest, that would prevent an egg from hatching.

Shooting adults, sub-adults, and young — shooting with firearms, typically shotguns or rifles. Shooting must adhere to local regulations and restrictions but could occur over water or land, during daylight or night with the aid of night vision, spotlights, firearm suppressors, or other modifications to reduce the noise or disturbance associated with shooting.

Traps/nets, capture by hand, and euthanasia — capturing DCCOs alive by hand or with traps, nets, or other means. Euthanasia techniques would follow American Veterinary Medical Association approved methods, such as cervical dislocation or carbon dioxide asphyxia.

2.1.3 Adaptive Management Framework

For this EIS, adaptive management is defined as evaluating the accuracy of the predicted environmental impacts, assessing the effectiveness of management actions, and modifying them as needed to ensure the purpose and need is met and levels of environmental effects predicted in Chapter 4 are not exceeded. The approaches taken in the alternatives follow the process described in the 2003 NEPA Task Force Report to the CEQ on Modernizing NEPA Implementation:

Predict à Mitigate à Implement à Monitor à Adapt

Prior dissuasion research and results from monitoring during those activities (Section 1.1.6) was used to *predict* impacts of the proposed alternatives. Each alternative outlines various measures to *mitigate* impacts to non-target species. Examples of this mitigation include timing activities prior to the nesting season or at night to avoid impacts as much as possible and applying known effective field techniques (human hazing, use of privacy fences, tunnels, etc.) to haze birds. The alternatives, including the preferred alternative/management plan, outline actions the Corps could *implement* to achieve the purpose and need of the EIS. Integrated into the alternatives are proposals to *monitor* the effects or results of actions. Monitoring is specifically designed to track dispersal in the estuary and abundance of DCCOs in other areas to determine distribution changes and to evaluate the effectiveness of the actions. This would allow the Corps the ability to *adapt* its management via changing field techniques in-season or between years to meet management goals.

The main goal of adaptive management for this EIS is to meet the purpose of and need for action and to ensure that management of the DCCO colony on East Sand Island would:

- Increase juvenile salmonid survival past East Sand Island to the baseline levels described in the FCRPS Biological Opinion (NOAA 2014)
- Reduce DCCO depredation of juvenile salmonids throughout the Columbia River Estuary

- Reduce the potential DCCO depredation impacts to other areas outside the Columbia River Estuary
- Minimize impacts to other birds on East Sand Island and in the Columbia River Estuary as much as feasible
- Implement passive methods that are cost effective and require less human presence in the long term

Adaptive management would allow for in-season and between year adjustments in application of management techniques based on knowledge gained during implementation. This includes adjusting field methods, such as technique, timing of activities, and duration of actions, and monitoring frequency. When implementing non-lethal and lethal techniques and monitoring, best management practices (timing of activities to minimize impacts, use of field techniques that have least impacts to non-targets as identified in the alternatives), as identified in the action alternatives, would be used to reduce the potential for dispersal, colony abandonment, and impacts to non-target DCCOs and other species (see USDA-WS 1997; Steinkamp et al. 2003; USFWS 2003, 2008; Pacific Flyway Council 2013). The Corps would convene an Adaptive Management Team, consisting of the cooperating agencies, to meet as needed to assess the effectiveness of, and guide future management actions. The Corps would be the decision making body for the Adaptive Management Team.

2.2 Detailed Description of Alternatives

Overview of Alternatives

Each alternative includes a suite of actions that make up a management plan to achieve the EIS purpose and need. As defined by RPA 46, non-lethal and lethal actions by the Corps related to DCCO management are restricted to the Columbia River Estuary, with primary focus on the breeding colony on East Sand Island. Outside of the Columbia River Estuary, the Corps would conduct monitoring efforts related to the EIS purpose and need.

The alternatives are presented in a nested structure (e.g., methods in Alternative B apply to C and D; and methods in Alternative C apply to D). When methods are identical between alternatives, this is noted with a short statement (e.g., same as Alternative B). The term "integrated" is used in Alternatives B–D, which means combining non-lethal and lethal methods during implementation. A depredation permit application would need to be submitted to the USFWS and approved prior to implementation of any of the alternatives that result in take.

Alternatives B–D describe a "phased" approach. Phase I (up to 4 years after the onset of management, or once the target reduction in DCCO predation is reached) includes actions to reduce the number of DCCOs on East Sand Island to 5,380–5,939 breeding pairs. This is a reduction of approximately 7,300 breeding pairs (56 percent reduction in colony size) from the average breeding colony size during 2004-2013 (12,917 breeding pairs). Phase II of Alternatives B and C (5 to 10 years after the onset of management) include actions to ensure the number of DCCOs on East Sand Island does not exceed 5,380–5,939 breeding pairs. In Phase II of Alternatives B and C no efforts would be made to maintain a minimum DCCO colony size on East Sand Island or to reduce the DCCO abundance below the target size. In Phase II of Alternative D, primarily non-lethal methods supported with limited egg take (same as Phase II of Alternative B and C) would be used to remove all remaining DCCOs from East Sand Island and redistribute them outside the Columbia River Estuary.

2.2.1 Alternative A – No Action

Under Alternative A, no action would be taken to resolve the depredation damage by managing the DCCO colony on East Sand Island. Efforts to improve juvenile salmonid survival to FCRPS baseline levels would need to be accomplished through other RPA actions (e.g., habitat improvement, increased fish passage at dams, management of other avian and mammalian predators). Hazing, habitat reduction experiments, and DCCO monitoring, management, and research efforts, conducted by the Corps on East Sand Island and in the Columbia River Estuary, would cease. RPA 46, requiring management of DCCOs in the estuary, would not be met.

If no actions are taken to manage the double-crested cormorant, predation rates on juvenile salmonids would likely remain higher than rates estimated during the environmental baseline of the FCRPS Biological Opinion and would continue to be a significant source of mortality. Additional measures would need to be identified to fill the gap in survival. These measures are unspecified at this time but would need to demonstrate a 3.6 percent increase in juvenile steelhead survival per the purpose and need. These actions could have potentially significant environmental and economic impacts given the magnitude of DCCO predation and the required survival improvement. Since these actions are unknown at this time, it would be speculative to evaluate the environmental and social effects. Therefore, the no action alternative in this document describes the effects that could continue to occur if no efforts were taken to manage the DCCO colony on East Sand Island per the revised RPA 46.

2.2.2 Alternative B – Non-Lethal Management Focus with Limited Egg Take

Summary — Under Alternative B, primarily non-lethal methods (i.e., temporary habitat modification and hazing) supported with limited egg take [500 eggs]) would be used to reduce the DCCO colony on East Sand Island to 5,380–5,939 breeding pairs (Phase I). Large-scale terrain modification on the west end of East Sand Island, supplemented with the non-lethal methods described above as necessary, would be used to ensure that this level is not exceeded (Phase II). Alternative B would disperse approximately 7,250 breeding pairs from East Sand Island. Non-lethal methods, particularly boat- and land-based hazing supported with limited egg take on Corps' dredge material islands [250 eggs], would be used to discourage dissuaded DCCOs from nesting and foraging throughout the 172 mile long Columbia River Estuary. Significant economic and labor resources for adequate hazing and monitoring efforts would be required to ensure DCCOs redistribute outside of the Columbia River Estuary. In Phase II, hazing efforts throughout the Columbia River Estuary would occur, as needed, but efforts are expected to be less than Phase I, assuming DCCOs emigrate from the estuary. Management would be considered successful once the DCCO target colony size is achieved and maintained, and the Corps would continue to implement primarily non-lethal methods supported with limited egg take, as necessary, to maintain the target size. Proposed lethal take would be up to 750 eggs per year (i.e., 500 on East Sand Island and 250 elsewhere in the Columbia River Estuary).

Feasibility — Based on past DCCO habitat modification and dissuasion research on East Sand Island (Roby et al. 2012, 2013, 2014), it is likely the DCCO target colony size could be achieved using the techniques described in Alternative B. It is also very likely DCCOs would continue to stay and prospect for nesting sites within the Columbia River Estuary (Roby et al. 2012, 2013, 2014). No prior studies or research was found that described using non-lethal techniques to permanently redistribute such a large number of DCCOs from as large of an open water system as the Columbia River Estuary (approx. 83,000 ha). Based on past research, hazing efforts in the Columbia River Estuary would likely be effective at precluding other large DCCO breeding colonies from forming and have measurable success at reducing nesting, roosting, or foraging at specific areas of the Columbia River Estuary. However, precluding foraging 100 percent throughout the entire Columbia River Estuary is not likely.

Smaller scale efforts than what are proposed under Alternative B have been successful in precluding DCCOs and other waterbirds from establishing nesting colonies on many of the Corps' dredge material islands over the past decades (see Roby et al. annual reports). However, precluding nesting colonies from forming throughout the entire Columbia River Estuary would depend on land access issues and the ability to locate and respond to DCCO nesting quickly.

Prior research has shown that coordinated and continued hazing can reduce or preclude DCCO foraging in particular areas within a large geographic context (see Mott et al. 1998, Wires et al. 2001, Dorr et al. 2010, Russell et al. 2012). Dorr et al. (2010) found that coordinated hazing methods supplemented with less than 6 percent lethal take reduced DCCO foraging attempts by 90 percent at Brevoort Lake and Durmmond Island, Michigan. These areas encompassed approximately 2,050 ha. The average hazing intensity to achieve a 90% reduction in foraging, measured as the average hours of active harassment effort per hectare per day of hazing, was 0.03 h/ha/d (Dorr et al. 2010). In comparison, the entire Columbia River Estuary encompasses approximately 83,000 ha, although much of this area would not be nesting, roosting, or foraging habitat (i.e., the deep central channel). To achieve half the level of hazing intensity as Dorr et al. (2010) in an area one-fourth the size of the Columbia River Estuary (20,750 ha) would require approximately 300 active hours of hazing per day of hazing, or approximately 30 people working 10 hour days (i.e., approximately 7-10 crews if 3-4 people per crew). If hazing were focused on more limited areas within the Columbia River Estuary, less personnel and hazing intensity would be needed.

Other large-scale dissuasion efforts have shown limited success in completely excluding DCCO foraging throughout large geographic areas (see King 1996, Mott et al. 1998, Tobin et al. 2002). Large-scale, coordinated night roosting harassment efforts have been conducted to disperse wintering DCCOs from the eastern portion of the Mississippi Delta, an area greater than 40,000 ha, to reduce impacts to catfish aquaculture (King 1996, Mott et al. 1998, Tobin et al. 2002). For example, Mott et al. (1998) harassed all known active roost sites in the eastern delta of Mississippi an average of 22 and 35 times during two consecutive years. During these harassment programs, DCCO abundance was reduced at some site-specific locations and DCCOs were found to change night roost more frequently; however, DCCOs typically moved to alternative non-harassed sites and continued to forage on catfish farms in the eastern delta (King 1996, Mott et al. 1998, Tobin et al. 2002).

Phase I - Management Actions to Reduce Colony Size on East Sand Island and Deter Nesting and Foraging in Columbia River Estuary

Field crew personnel would arrive on East Sand Island prior to the breeding season (Feb-Mar) to transport supplies and equipment and make any necessary preparations for management that year. Temporary housing (i.e., tents or weatherports) would be constructed and maintained, as personnel would be present 24 hours a day during the period of active hazing. Individuals would follow designated travel routes to minimize potential impacts on other wildlife. These paths are located along the northern beaches and through vegetation to colony sites. Travel by all-terrain vehicles (ATVs) would occur along compacted sand along the shore or on previously established ATV paths. Boat landing and loading points would be chosen to eliminate potential disturbance. Protective fences would be used to conceal hazing activities from designated nesting areas. Established best management practices for housekeeping would be used to minimize human impacts on vegetation.

Reducing Available Habitat on East Sand Island

Similar to dissuasion research methods, habitat modification combined with human hazing would be used to restrict DCCOs to a designated area (see Figures 1-5 and 4-6). Privacy fences would be constructed to designate this area prior to birds arriving on the island (Feb-Mar). Based on prior estimated maximum DCCO nesting density on East Sand Island (1.28 nests per square meter; BRNW unpublished data), the amount of available nesting habitat may ultimately need to be reduced to 1.04–1.15 acres or less in order to achieve the target colony size. There is little evidence from past dissuasion research on East Sand Island or other DCCO colonies that density would greatly exceed prior estimates, as DCCOs maintain the relative spacing necessary to avoid bill strikes and stealing of nesting materials from neighboring nesting DCCOs. Therefore, available nesting habitat would be reduced per the following (Table 2-1) unless densities increase and further reduction is needed.

TABLE 2-1. Proposed Reduction in Nesting Area.

Year	Available Nesting Habitat*	Estimated # of Pairs (based on nesting density of 1.28 nests per square meter)
Year 1	2 acres	10,360 pairs
Year 2	1.5 acres	7,770 pairs
Year 3	1.1 acres	5,698 pairs
Year 4	Reduce further or maintain	5,380–5,939 breeding pairs

*If nesting density exceeds prior estimates, greater habitat reductions would be needed to achieve the target size.

Reducing acreage over a period of 3 years would allow for incremental dispersal among years (approximately 2,000-3,000 breeding pairs per year), rather than all dispersal in one year. Habitat modification would occur on the western portion of East Sand Island, where DCCOs have previously nested or attempted to nest (an area of approximately 16 acres; Figure 2-1), but could be used in other areas on the island if DCCOs move into those areas. Placement of flags, ropes and stakes in a grid pattern would be applied as needed to further reduce available habitat on the island. To the extent possible ground disturbing work would be focused outside of the breeding season and during time periods and in locations where impacts to target and non-target species would be less. Any temporary habitat modification techniques would be removed, when appropriate, to reduce potential impacts to non-target species and to ensure materials are not damaged or lost over winter.

FIGURE 2-1. DCCO nesting area on East Sand Island. DCCO use and nesting areas are based on distribution of nesting and roosting in 2010, prior to dissuasion experiments. The yellow boundary on land is the area where the majority of management actions would occur.

Hazing on East Sand Island

Personnel would observe DCCOs from blinds or similar structures, and the following observations or behaviors outside of the designated nesting area would trigger a hazing event: 1) DCCO breeding behavior (i.e., courtship, nest building, or copulation); 2) more than 50 DCCOs loafing in an area; and 3) DCCOs present at twilight (i.e., preparing to roost overnight). Hazing triggers would be adapted if they are ineffective at producing desired results. Other visual and noise deterrents could be used during hazing events as needed depending on effectiveness of human hazers and knowledge gained during implementation. Given the magnitude of the colony size and presence of other nesting birds, some level of egg take would likely be necessary to ensure that hazing can continue after the beginning of the breeding season and the alternative is feasible to implement. Take of 200 DCCO eggs was authorized for past dissuasion research on East Sand Island, although actual take was minimal (e.g., 1 egg in 2012; BRNW 2013a). Because EIS actions are greater than prior research efforts, take of 500

DCCO eggs would be requested in a depredation permit application the first year and adjusted accordingly thereafter.

Hazing in the dissuasion area on East Sand Island would be implemented frequently and repeatedly during the nest initiation period. During 2012 dissuasion research, hazing in the dissuasion area was conducted from April 20–June 12 (approximately 8 weeks), with an average of five (range = 1-19) hazing events per day (Roby et al. 2013). Efforts and date range were slightly greater in 2013 (i.e., April 13–June 30, approximately 11 weeks in western dissuasion area; April 26–June 13, approximately 7 weeks in eastern dissuasion area; 4 [range = 0-21] hazing events per day on average; Roby et al. 2014). Since a larger area for hazing would be included and more DCCOs dissuaded under Alternative B than prior research, a greater hazing effort would likely be needed. Management-related activities would likely extend greater than 11 weeks and into the late chick or early fledgling stage of the breeding season.

Impact Avoidance Measures

Preference would be given to visual deterrents first and noise deterrents second as a means to minimize impacts to non-target species. Monitoring to determine when hazing events are needed would be done via field crew observations from ground positions. DCCOs and other birds would be monitored from concealed areas or distances sufficient not to induce flushing. If monitoring within the colony is necessary, it would be kept to as short a time duration as possible and would not occur in severe weather conditions or when higher than normal levels of predation might be expected. Egg take would be minimized to the extent possible by: 1) implementing actions frequently enough so that nest destruction and hazing occur before egg laying; 2) ceasing hazing and habitat modification techniques within a sufficient distance of an active nest (i.e., once an egg is laid); 3) removing nesting materials or destroying nests only if the nest does not have egg(s) in it; and 4) reducing or ceasing hazing if higher than normal levels of subsequent predation might be expected. Table 2-2 provides a summary of non-lethal methods and adaptive responses for Alternative B.

TABLE 2-2. Non-Lethal Methods and Adaptive Response.

Action	When Used	Adaptive Response
Designate Nesting Area	Prepared prior to nesting season (Feb-Mar). Habitat reduction is based on known nesting densities (1.28 nests per square meter) and reduced to allow for incremental dispersal of 2,000-3,000 DCCOs.	Based on peak colony size estimates and density; change available nesting area as needed to allow for incremental dispersal or if densities increase greater than 1.28 nests per square meter. If target size not achieved with 1.1 acres, apply further habitat reduction to 0.25-0.5 in the following years.
Human Hazing	Outside designated nesting area if breeding behavior observed, >50 DCCO observed loafing, or DCCOs observed at twilight about to	Reduce threshold to 25 (or fewer) DCCOs loafing if greater hazing intensity needed. If DCCO habituate to human hazing, apply visual deterrents to increase effectiveness in hazing. Dogs could be used selectively if

Action	When Used	Adaptive Response
	roost.	human hazing is not effective.
Visual Deterrent	If DCCO habituate to human hazing.	If DCCO habituate to visual deterrents, apply noise deterrents.
Noise Deterrent	If DCCO habituate to human hazing and visual deterrents.	If DCCO habituate to noise deterrents, combine additional methods.
Temporary Habitat Modification (stakes, ropes and flagging)	Concurrent with hazing. Apply temporary habitat modification prior to or during nesting season.	Increase amount and area.
Egg Collection	Concurrent with hazing. The Corps would submit a depredation permit application for take of up to 500 DCCO eggs.	Take numbers adjusted in subsequent years based on take during the prior year.

Hazing DCCOs in the Columbia River Estuary

Boat- and land-based hazing in the Columbia River Estuary to deter DCCO nesting, roosting, and foraging would begin concurrent with monitoring (see below) and management actions on East Sand Island. Primary hazing locations and hazing triggers are identified in Table 2-3. Boat-based hazing would be used to deter DCCO foraging, particularly at up-river locations where predation impacts are known to be greater (Collis et al. 2002). If necessary, noise deterrents (e.g., pyrotechnics, cracker shells, etc.) would be used to aid hazing efforts over open water.

TABLE 2-3. Anticipated Estuary Monitoring and Potential Hazing Locations.

Key Estuary Monitoring/Hazing Locations*	Hazing Triggers
Astoria-Megler Bridge	1) Breeding behavior is observed 2) >50 DCCOs loafing or roosting 3) DCCOs present at twilight
Rice Island	
Miller Sands Spit	
Pillar Rock Island	
Lewis and Clark Bridge	
Troutdale Transmission Tower	
Willamette Falls/Oregon City	
Bonneville Dam	
Tongue Point Piers	

*Additional locations for hazing would be determined from the results of surveys and monitoring.

On dredged material islands, land-based hazing and habitat modification could occur early in the nesting season and at a distance sufficient to prevent impacts to non-target species, especially streaked horned larks. Due to the potential for adverse effects to streaked horned larks, an adaptive monitoring and hazing plan would be coordinated with the USFWS Endangered Species program. Efforts to haze on lower estuary islands would be integrated with on-going avian predation management of dredged materials sites under the Corps' Channel and Harbors program, which monitors dredged material sites for DCCO and Caspian terns and implements hazing as needed to prevent these species from nesting (see Chapter 4, section 4.5). The Corps would submit in a depredation permit application for take of up to 250 DCCO eggs on the Corps' dredged material sites so that placement of temporary habitat modification (flags, ropes and stakes) and hazing can continue after the beginning of the breeding season and the alternative is feasible and effective to implement.

It may not be possible to entirely limit DCCO expansion into new areas in the estuary, given the geographic scope, difficulty in accessing some sites due to logistics (i.e., Astoria Bridge; Figure 2-2) or landowner permission, and potential overlap with ESA-listed species (i.e., streaked horned lark) or other species of conservation concern. Potential DCCO dispersal locations within Columbia River Estuary may be in areas that the Corps does not own or have the right to access. Any potential actions in these areas would need to be coordinated with the appropriate landowner(s) or interested parties, prior to implementation.

FIGURE 2-2. DCCOs using Astoria-Megler Bridge in 2012 (Photo Credit: BRNW).

Monitoring and Adaptive Management

Monthly aerial surveys and high resolution aerial photographs would be taken over East Sand Island and other locations in the Columbia River Estuary during the breeding season to estimate peak colony size. Target size achievement would be based upon the peak breeding season abundance count (i.e., typically late incubation). The amount of egg take and any other reporting specifications of a depredation permit would be monitored and reported. PIT tag recoveries on East Sand Island would occur after the breeding season. The average annual percentage of available PIT tags that are recovered in the DCCO nesting area would be evaluated in context of relevant factors to assess DCCO predation rates of juvenile salmonids. DCCO counts and behavior and response of non-target species would be monitored and recorded.

Aerial, boat, and land-based surveys would be conducted in the Columbia River Estuary to determine if DCCOs dispersed from East Sand Island are relocating within the estuary. DCCO abundance surveys would occur from the onset of management actions on East Sand Island until July 31 each year. Boat- and land-based surveys would initially be conducted at least every other day on the primary monitoring locations identified in Table 2-3. Approximately five to eight monitoring crews would be deployed throughout the Columbia River Estuary. Each crew would be responsible for monitoring approximately 30–40 RM of the Columbia River Estuary (172 RM in total). The number of DCCOs roosting, resting, or attempting to nest at specific locations would be counted and recorded. Additionally, monitoring crews would conduct short-interval point counts (i.e., 15 minute) from set, stationary positions within their monitoring areas multiple times per day (i.e., morning, mid-day, and evening) to monitor abundance of foraging and flying DCCOs.

Priority areas in coastal Washington and Oregon where there are fish predation concerns and the potential for DCCO increases were identified through input from cooperating agencies and the utilization of past results from dissuasion experiments. In Oregon, these areas are the coastal estuaries and lakes. In Washington, these areas are Willapa Bay National Wildlife Refuge, Gray's Harbor, Puget Sound, and San Juan Islands. The Columbia River Basin above the Bonneville Dam was also identified as a priority area. Annual aerial surveys of these areas would occur at least once during the peak breeding season from April 1–July 31 to monitor abundance. Surveys in the Columbia River Basin above Bonneville Dam would occur in coordination with the Corps' Walla Walla District's Inland Avian Predation Program.

If monitoring efforts show DCCO increases in areas, the Corps would notify and coordinate with ODFW, WDFW, or other appropriate land managers. The agency or entity that would lead any potential management actions and the extent of management techniques could vary, depending upon the location and DCCO impacts. Mere presence of DCCOs may not indicate a problem that needs to be addressed. If conflicts result, the best management strategy for addressing any potential DCCO conflicts at these locations would be determined in the future and should follow existing and appropriate processes for resolving DCCO conflicts within the Pacific Flyway (Pacific Flyway Council 2012). Data collected from these monitoring efforts would augment the USFWS and Pacific Flyway Council regional monitoring strategy for the western population of DCCOs (Pacific Flyway Council 2013). This monitoring strategy was developed through the Pacific Flyway Council as a joint effort between federal and Pacific Flyway state agencies to assess DCCO population status, distribution, and trends (Pacific Flyway Council 2013). The Corps would follow the prescribed monitoring protocols, coordinate efforts, and share monitoring data to the greatest extent possible with these monitoring efforts.

In-season and prior year observation of DCCO nesting locations and density on East Sand Island would be used as a guide to determine the amount of available nesting area needed to achieve the target size. Dispersal levels would be estimated from colony counts on East Sand Island and abundance surveys in the Columbia River Estuary, above Bonneville Dam, and in priority coastal areas in Washington and Oregon. The initial survey frequency and areas described above for East Sand Island, within the Columbia River Estuary, above Bonneville Dam, and along coastal Washington and Oregon could be adjusted based upon DCCO response and knowledge gained during implementation under a multiple-level adaptive approach, with increasing monitoring frequency based on particular thresholds (Table 2-4). Individual marking techniques (i.e., primarily satellite tags, but also VHF radios and bands) could be used to supplement abundance surveys to determine dispersal and redistribution of DCCOs from East Sand Island if abundance surveys are determined to be inadequate (i.e., observed abundance is 70% or less than expected abundance one week after a culling event, this number of DCCOs is not detected in Columbia River Estuary, and tri-annual surveys are ineffective in determining abundance changes.). Capture and marking of DCCOs if determined necessary would occur early in the breeding season prior to any subsequent hazing activities. Survey frequency and the amount of individual marking could change based upon information needs and knowledge gained during implementation.

The amount of nesting habitat reduction on East Sand Island and frequency and duration of hazing on East Sand Island and in the Columbia River Estuary would be adjusted so that incremental dispersal of DCCOs from the Columbia River Estuary would occur each year until the target size is achieved. Primary non-lethal techniques could be changed or adjusted based on knowledge gained during implementation (Table 2-4). Adjustments in techniques would be coordinated through the Adaptive Management Team and specified in depredation permit applications. Hazing triggers on East Sand Island and in the Columbia River Estuary would be adjusted if they are inadequate in achieving the desired response. Hazing efforts in the Columbia River Estuary would be adjusted to minimize impacts to or take of other species, particularly streaked horned larks. The amount of egg take requested in an annual depredation application would be adjusted based on the prior year's results (Table 2-4).

TABLE 2-4. Monitoring and Adaptive Response Phase I.

Management Need	Proposed Monitoring and Frequency	Adaptive Response
Detect Reduction of Colony Size on East Sand Island	Monthly aerial surveys and high resolution photographs, visual observations of field crews monitoring for dispersal	Increase frequency of aerial surveys to weekly if observed abundance is 70 percent or less than the expected abundance one week after a culling session. Management actions could be changed or scaled back until abundance returns to at least 90 percent of the expected abundance.
Monitor and Hazing of DCCOs in Columbia River Estuary at Priority Areas	Boat- and land-based surveys and hazing every other day per week during peak nesting, surveys every three days outside of peak nesting in foraging area of East Sand Island. Bi-weekly surveys in upriver locations. Monthly aerial surveys.	Increase frequency of boat- and land based surveys and hazing to daily if surveys in the estuary detect >4,000 DCCOs and DCCOs demonstrating breeding behavior at locations other than East Sand Island. At particular locations, decrease frequency of surveys and hazing to weekly or daily if no DCCOs present at location in three consecutive surveys. Aerial surveys same threshold as East Sand Island.
Detect DCCOs Outside of Columbia River Estuary - (Columbia River Basin, Coastal OR and WA) - Monitor Western Population of DCCOs	Aerial surveys Level 1 - Annual Level II - Bi-annual Level III - Tri-Annual	I Increase frequency of survey to next level if observed abundance is 70 percent or less than the expected abundance one week after a culling session and this number of DCCOs is not detected in the Columbia River Estuary. Surveys coordinated with USFWS seabird surveys and Pacific Flyway Council monitoring strategy. Individual marking if observed abundance is 70 percent or less than the expected abundance one week after a culling session, this number of DCCOs is not detected in Columbia River Estuary, and tri-annual surveys are ineffective in determining abundance changes.
Minimize Impacts to Non-target Species	Daily observations of field crews, DCCO daily responses, nesting attempts and productivity, presence of bald eagles and response of non-targets	If monitoring indicates effects to non-target species greater than anticipated and evaluated in the EIS, management actions would be scaled back or techniques changed to more passive measures in-season and in future years. Management strategies would change to more habitat modification prior to nesting season (April-May) in the following year. Boat-based or aerial monitoring would occur at a distance that does not induce flushing.
Minimize Impacts to Streaked-Horned Larks in Columbia River Estuary	Boat- and land-based surveys (some surveys are ongoing per Corps' Channels & Harbors Program) weekly to daily, observations by field crews monitoring for DCCOs	Coordinate surveys with Corps' Channels & Harbors Program and develop hazing effort consistent with ESA requirements; annual meetings with USFWS to determine future monitoring and management actions
Assess Predation Rates	PIT tag recoveries post-breeding season	No adaptive response in Phase I because the time period is too short to determine trends. Use is for evaluation of overall multi-year effectiveness of management.

Phase II - Management to Ensure Colony Size Goals are Retained

The goal of Phase II is to transition to lower maintenance non-lethal techniques and reduce the amount of human presence needed on the island while still ensuring the target colony size is not exceeded. This would be accomplished through terrain modification and supplemented with temporary habitat modification and hazing, as necessary. Hazing techniques would be the same as described in Phase I, and the extent of hazing would depend upon DCCO response to management and the capacity of the colony to increase in size after Phase I targets are reached. Based on knowledge gained during Phase I, a minimal amount of egg take on East Sand Island (up to 500 eggs) would most likely be requested in a depredation permit application to ensure that the alternative can be implemented effectively.

Modification of the existing terrain (Figure 2-3) would occur through the excavation of sand (approximately 300,000 cubic yards on the western portion of the island) in order to inundate the DCCO nesting area. Sand would be excavated to an elevation that would be inundated at least once per week during April 1-July 15, and to a water depth of 6 inches to 1 foot to preclude nesting attempts or successful nesting. The shoreline would be armored with added rock (approximately 30,000 cubic yards of riprap) on the northern shore to reinforce the island and maintain stability of the Columbia River Federal Navigation Channel.

Disposal locations of excavated sand would be located on the designated Caspian tern colony to improve nesting habitat and in other upland areas on the eastern portion of the island and in upland areas where feasible. Disposal of sand could also be used for beach nourishment on the southern and eastern portions of the island and/or placed between the pile dikes on the southern shoreline. Disposal locations would be selected to avoid and minimize impacts to delineated wetlands on the central portion of the island. Two delineated tidal estuarine wetlands (approximately 0.6 acre) on the eastern portion of the island could be filled during disposal. Construction activities for terrain modification and associated work would take place within the in-water work window (November 15-February 15).

Excavation of sand would occur to create two "lagoon" type areas located on the western portion of the island (darker shaded green, Figure 2-4), designed with an elevation range of 1.7–2.2 m (NAVD88) and generally sloping downward from south to north. These lagoon areas would be open to tidal fluctuations via five channels on the north side of the island. Terrain modification was designed to encourage the establishment of mud flats, marshes, and other low-elevation herbaceous vegetation, and to be resilient to sea level rise over a 50-year planning horizon (see Chapter 4, section 4.5.3).

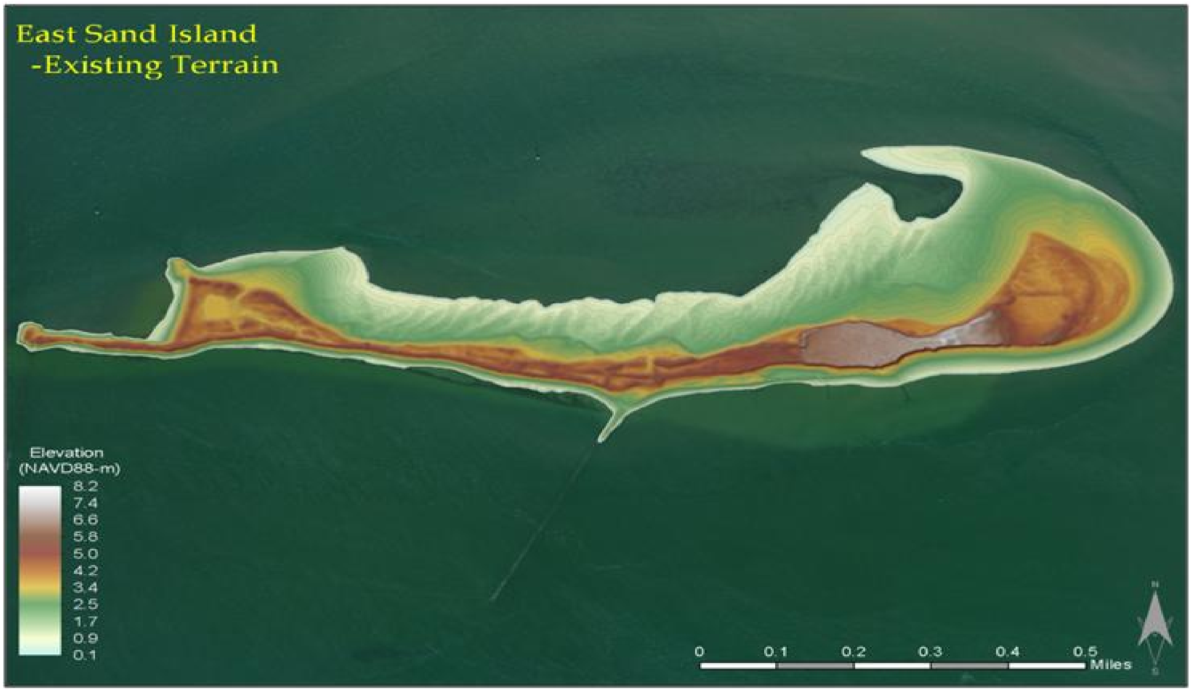


FIGURE 2-3. Existing terrain of East Sand Island, based on 2009 LiDAR data.

FIGURE 2-4. Proposed terrain modification, creating "lagoon" type areas in the DCCO nesting area on the western portion of East Sand Island.

Monitoring and Adaptive Management

Annual monitoring to estimate DCCO abundance, nesting density, and PIT tag recoveries on East Sand Island would continue as necessary. Peak breeding season abundance would be determined from counts during late incubation. A three-year average estimate of peak breeding season colony size would be used for evaluating actual colony size to target size. If personnel are on the island conducting hazing activities, DCCO counts and behavior and response of non-target species would be monitored and recorded. PIT tag recoveries would be used to evaluate overall effectiveness of management actions in reducing predation of juvenile salmonids. Due to annual variability in predation impacts, monitoring would likely need to occur over a longer period of time (5-10 years) to assess overall trends and effects accounting for yearly fluctuations.

Abundance surveys would continue, as needed, to determine DCCO abundance at other locations within the Columbia River Estuary. The same strategy as Phase I would be used to deter DCCO nesting and foraging in the Columbia River Estuary. Efforts would likely be less in Phase II if hazing efforts in Phase I are successful in redistributing DCCOs outside of the Columbia River Estuary. Monitoring would likely be less than during Phase I and would concentrate on known areas of concern or interest. Annual monitoring efforts in coastal areas of Washington and Oregon and above Bonneville Dam would cease in Phase II. Monitoring efforts would match or supplement those of the Pacific Flyway Council monitoring strategy (Pacific Flyway Council 2013), which calls for monitoring at selected locations every three years.

Based on Phase I and II implementation and response of DCCOs, management actions would be adjusted accordingly to ensure the target colony size and associated base period DCCO predation conditions are not exceeded. A long-term hazing program would likely be needed to deter DCCOs from breeding at other locations throughout the Columbia River Estuary. Once the target colony size is reached on East Sand Island, boat-based hazing to deter DCCO foraging would decrease or cease, unless DCCO foraging occurs in areas of predation concern, such as below dams or at other upriver locations. Based on knowledge gained during Phase I, a limited amount of egg take (up to 250 eggs) on the Corps' dredged material sites could be requested in a depredation permit application in order to ensure the alternative can be implemented effectively.

Continued non-lethal management on East Sand Island is expected to be necessary to slow or stop abundance increase of the colony. These actions would be conducted as necessary and would continually transition to methods that are most effective, least impactful to non-target species, and require least management effort and cost. Actions would be considered successful when the average 3-year peak colony size estimate does not exceed the target colony size while no management actions are conducted. The Adaptive Management Team would develop a more detailed strategy outlining actions and appropriate monitoring based on Phase I and II results for long-term DCCO management in the Columbia River Estuary. Continuance of long-term monitoring and management would depend upon available appropriations and future management needs. Additional environmental review may be needed at that time.

2.2.3 Alternative C – Culling with Integrated Non-Lethal Methods Including Limited Egg Take (*Preferred Alternative/Management Plan*)

Summary — Under Alternative C, the Corps would implement primarily lethal methods (i.e., on- and off-colony shooting) during Phase I to reduce the DCCO colony on East Sand Island to between 5,380 and 5,939 breeding pairs. An adaptive approach would be used to achieve the East Sand Island DCCO target colony size. The Corps would initially undertake a 4-year lethal strategy to achieve the target size (by the end of 2018 if implementation began in 2015). Under a 4-year lethal strategy, 20.3 percent of the DCCO colony would be culled each year (mid-point between the two carrying capacity scenarios modeled in Appendix E-2), resulting in a total take of 15,956 DCCOs in all years (5,230, 4,270, 3,533, and 2,923 DCCOs in years 1 to 4, respectively; Table 2-5). The Corps would submit an annual depredation permit application to the USFWS for the proposed individual take levels and associated nest loss from take of those individuals. The 4-year lethal strategy could be adjusted to a 3- or 2-year strategy by increasing take levels after the first year of lethal management, depending upon DCCO response and dispersal levels and culling efficiency (i.e., the number of DCCOs lethally taken per day of culling) during year 1 (see Adaptive Management below and Table 2-5). The take levels proposed under all year strategies could decrease if peak observed annual colony size during late incubation, accounting for expected annual variation (see below), becomes lower than model predicted colony size. If peak observed colony size becomes greater than model predicted colony size, additional NEPA review and supporting analyses would be required for increased take levels greater than those proposed and analyzed in the EIS. Any adjustment to year strategies or proposed take levels would occur in coordination with the Adaptive Management Team. The same non-lethal methods supported with limited direct egg take (up to 750 eggs total; 500 on East Sand Island and 250 for other locations in the Columbia River Estuary) described in Phase I of Alternative B would be used to prevent expansion of the DCCOs to other areas on East Sand Island and to other locations within the Columbia River Estuary. Phase II would be the same as Alternative B.

Feasibility — Prior large-scale culling efforts at other DCCO breeding colonies have been documented (Bedard et al. 1997; Ontario Parks 2008). At Presqu'ile Provincial Park, approximately 11,000 adult DCCOs were culled in 3 years using multiple (5 or fewer) shooters working within DCCO colonies during the day. The time duration to conduct culling was short and also included greater levels of concurrent nest destruction (6,030 DCCOs culled in 13 days in 2004; 1,867 DCCOs culled in 5 days in 2005; and 2,927 DCCOs culled in 5 days in 2006; Ontario Parks 2008). During 1989–1992 (i.e., 4 years), approximately 8,000 adult DCCOs were culled within a complex of breeding colonies within the St. Lawrence River Estuary. Rates of less than or equal to 75 DCCOs culled per shooter, per hour, were reported (Bedard et al. 1997).

The field techniques proposed for Alternative C would likely be as, or more, effective in lethally taking DCCOs than the studies cited (due to timing of activities, night shooting, use of firearm suppressors, etc.); thus, feasibility of achieving potential target take levels and doing so within a relatively short time period on-island (i.e., less than 2-3 weeks) is high. Given the magnitude of take, regulatory prohibition on use of decoys, and general habituation of DCCO to being hazed over water, lethal removal of DCCO off-island is expected to be relatively low and the majority of culling would likely occur on-island. Of the life stages on which lethal take could occur, take of individuals was determined to be the most feasible approach to achieving the target colony size by the end of the 2018 timeframe of the 2014 FCRPS Biological Opinion (NOAA 2014) because DCCOs typically breed in their third year (Hatch and Weseloh 1999) and there would be a multiple year delay before decreased recruitment begins to affect the colony size.

Phase I - Management Actions to Reduce Colony Size on East Sand Island and Deter Nesting and Foraging in Columbia River Estuary

The same field crew efforts and similar non-lethal methods (use of privacy fences and human hazing, supplemented with other temporary habitat modification measures) supported with limited direct egg take up to 750 eggs (i.e., 500 on East Sand Island and 250 for other locations in the Columbia River Estuary) as described in Alternative B would be used concurrently with lethal methods on East Sand Island to deter DCCOs from nesting outside of the designated area. Boat-based hazing and hazing on East Sand Island would occur separately from or in conjunction with shooting. Noise associated from boat-based shooting would also be used to deter DCCO foraging. Noise deterrents would be used as appropriate in hazing efforts over water. The extent of human hazing and habitat modification would depend on DCCO response. Since lethal take of individuals would also be used to achieve the target colony size, habitat reduction targets and hazing efforts would likely need to be less than those described in Alternative B.

Take of individuals would occur by use of firearms with non-toxic ammunition. Lethal take would occur in two generally defined areas in relation to East Sand Island: 1) off-island in foraging area and 2) on-island. Early in the season, and possibly throughout the duration of lethal take, culling would be attempted off-island from boats or at a distance sufficient enough to not disturb and prevent DCCOs from nesting within the designated nesting area on East Sand Island. The lethal technique used for off-island culling would be shooting with shotguns and directly approaching DCCOs with boats and shooting once in effective range or situating boats and individuals in the flight path of DCCOs. Pursuant to depredation regulations (50 CFR 21.41), shotguns would not be larger than 10-gauge and decoys and concealment would not be used to entice birds into gun range.

Culling on-island would include multiple individuals shooting from observation points (ground or elevated) and existing structures on East Sand Island using small caliber rifles. Culling would occur periodically on-island, with the intention that a primary core nesting area would be left unaltered if take targets can be achieved. Personnel would monitor remaining DCCOs to determine responses and potential for dispersal or abandonment. After a culling event, the island would be left undisturbed until another culling session occurs. Culling may occur during the day on-island, if privacy fencing is sufficient in precluding disturbance in other areas, and if proximal DCCOs are not disturbed when lethal take occurs. However, if day-time culling on-island results in high levels of dispersal or impacts to non-targets, culling on-island would occur primarily or exclusively at night. If noise from firearms causes excessive dispersal or indirect impacts to non-targets, silencers and sub-sonic (i.e., slower than the speed of sound) shot would be used primarily or only.

The Corps would initially undertake the 4-year lethal strategy following the proposed annual take levels in Table 2-5 (see Adaptive Management section below for how take levels could be adjusted in future years). The majority (approximately 70%) of DCCOs arrive on East Sand Island in mid- to late April (Roby et al. annual reports). DCCOs are present on the island beginning late March and active nests are present late April (see Table 4-1). Culling on-island would initially be attempted as early in the year as possible and before active nests are present to determine the feasibility of lethally removing individuals without causing excessive DCCO dispersal. Excessive dispersal would be determined by a dispersal threshold, which is identified as an observed abundance that is 70 percent or less than the expected post-take abundance one week after the culling event. For example, if observed abundance was 5,000 breeding individuals at the time of the culling event, and 500 breeding individuals were culled, expected abundance would be 4,500 breeding individuals. An abundance of 3,150 (0.7 x 4,500) breeding individuals would be the dispersal threshold. If observed abundance one week after the culling event is less than the dispersal threshold, culling individuals on-island would temporarily cease until observed abundance returns to at least 90 percent of the expected post-take abundance. In the example provided, this would be 4,050 breeding individuals (0.9 x 4,500]). Once observed abundance returns to at least 90 percent of the expected abundance, culling could continue. If DCCOs appear to become more sensitive to culling early in the year (i.e., greater levels of dispersal occur in future culling sessions), culling would occur during a timeframe when DCCOs are more committed to nest at East Sand Island (post-late April when DCCOS are attending active nests). The same dispersal thresholds (70% and 90%) would be used for modifying the frequency of culling session on-island once active nests are present. Active nests (i.e., time period from egg laying to presence of fledglings) typically are present on East Sand Island from March 27 to July 5. Direct take of active nests is not proposed but their loss is expected to occur indirectly from take of breeding adults that are actively nesting when culled (Table 2-5). When determination of active nest loss can be made in the field, the actual number of active nests lost would be recorded and reported. When determination of active nest loss cannot be made in the field or the date that active nests are first present on East Sand Island during a given year is unknown, the date range of March 27 to July 25 would be used to report associated nest loss.

TABLE 2-5. Proposed Take Levels under the 4-year Lethal Strategy and the Adjusted 3- and 2- year Lethal Strategies.

	4-year strategy			Adjusted 3-year strategy			Adjusted 2-year strategy		
Year	# ind taken	% of colony	associated active nests lost[1]	# ind taken	% of colony	associated active nests lost[1]	# ind taken	% of colony	associated active nests lost[1]
1	5230	20.3%	5230	5230	20.3%	5230	5230	20.3%	5230
2	4270	20.3%	4270	6071	28.8%	6071	10156	48.0%	10156
3	3533	20.3%	3533	4489	28.8%	4489			
4	2923	20.3%	2923						
Total	15956		15956	15790		15790	15386		15386

[1]Lethal take of individuals is the proposed direct lethal action. Nest loss values represent the upper bound of potential egg loss that could occur indirectly from taking individuals. The period of active nests is from egg laying to presence of fledglings. For associated active nests lost, actual numbers would be recorded and reported when determination in the field can be made. If determination cannot be made in the field, March 27 to July 25 would be date range used to report associated active nests lost.

[*] Take numbers and percentages are mid-points between the two carrying capacity scenarios modeled in Appendix E-2. The Corps would initially undertake the 4-year lethal strategy and use the associated take levels when applying for a depredation permit application. The adjusted 3-year or 2-year could be selected if the proposed take levels for the respective strategy are expected to be achieved by June 26 (pending implementation) and the frequency of culling to achieve the proposed take levels would not exceed the lower dispersal threshold (observed abundance 70% or less than the expected abundance one week after a culling session).

Carcasses would be retrieved and removed immediately or as soon as feasible, after the conclusion of lethal take. This would occur on-island after a culling session, in a manner that minimizes disturbance to non-target nesting DCCOs and other non-target nesting species. If shooting occurs at night, retrieval could occur the following day. For culling off-island, where culled individuals would fall in open water, take activities would cease frequently enough in order to retrieve culled individuals while they are in the proximal area, or other boats and personnel would monitor or be positioned away from the site of culling to retrieve carcasses (i.e., downriver, along shorelines). DCCO carcasses would be examined for leg bands or other markers, and reported to the USGS Bird Banding Laboratory or other appropriate entity. When possible, lethally removed birds or eggs would be donated to a public educational, scientific institution, Non-Eagle Feather Repositories, or other entities authorized to possess birds. Carcasses not donated for these purposes would be disposed of following standard conditions of 50 CFR 21.41, which include burial and incineration, and any special conditions specified in a depredation permit.

Impact Avoidance and Minimization Measures

To minimize take of non-target species during culling on- and off-island a shooting protocol would be developed prior to implementation. Shooters would receive species identification training, and trained individual(s) or biologist(s) in species identification would be present when lethal take occurs to minimize take because of misidentification (i.e., Brandt's and pelagic cormorants). Areas or lethal take opportunities that have a high concentration of non-target species present would be avoided. Species would be identified prior to night shooting, and, if there is a high concentration of non-target species in the area that could be misidentified, these areas would be denoted and avoided. Techniques and methods would also be modified to minimize take of non-target species if it should occur. These actions include increasing the amount of training for personnel, increasing the number of individuals in the field adequately trained in species identification, removing personnel unable to adequately perform duties, ceasing that particular lethal technique, or avoiding mixed species areas.

To assure culling would not result in risk to human safety, personnel would adhere to all safety standards of firearm operation and training as described in the USDA-WS Policy Manual, Directive 2.615 (Firearm Use and Safety), and Firearms Safety Training Manual. The use of firearms would be conducted in accordance with all local, state, and Federal regulations. Personnel would implement precautionary measures to reduce risk to public safety, such as positively identifying target animals before shooting, ensuring a backstop should the bullet miss, using rifles that fire single projectiles per shot, and using only specially trained personnel. To the extent possible, areas and times of public usage would be avoided when implementing management actions on- and off-island. Monitoring would occur before shooting to ensure people are not present within the targeted area or shooting direction. East Sand Island would be closed to the public during implementation, and any violations of the closure or interference to management activities would be enforced as specified in 18 U.S.C. 111.

Hazing DCCOs in the Columbia River Estuary

Non-lethal techniques supported with limited egg take (up to 250 eggs) to deter DCCO nesting and foraging in the Columbia River Estuary would be the same as Phase I of Alternative B.

However, hazing efforts needed for Alternative C are likely to be less than Alternative B, because fewer DCCOs are expected to be dispersed from East Sand Island.

Monitoring and Adaptive Management

Monitoring on East Sand Island would be similar to Phase I of Alternative B (see above and Table 2-4), except individual marking is not proposed. Additionally, all individuals taken and associated active nests lost would be recorded, and information would be provided to meet reporting requirements. Informal reporting of field conditions and events could occur more frequently.

Aerial, boat-, and land-based surveys would be conducted in the Columbia River Estuary to determine if DCCOs dispersed from East Sand Island are relocating within the estuary. Short-term and short-distance dispersal from management activities (Roby et al. 2012, 2013, 2014) and daily movements for foraging (foraging range typically < 25 km; Anderson et al. 2004a) are expected. Monitoring would focus on the key locations identified in Table 2-3 and upriver locations greater than the expected foraging range of DCCOs. The size of the Columbia River Estuary east of the typical 25 km foraging range is 50,600 ha, approximately 39 percent smaller than the entire Columbia River Estuary (83,000 ha). Surveys would closely coincide to when culling sessions occur on East Sand Island. During the primary lethal take period on East Sand Island, surveys, similarly described in Phase I of Alternative B, would be conducted 2-3 days after the culling session to assess dispersal levels. Surveys would decrease in frequency after take ceases and would supplement monthly aerial surveys, as necessary. Less than five crews would likely be needed. Since the DCCO colony on East Sand Island would be reduced through abundance reduction, not redistribution, and adaptive management would be used to minimize the potential for DCCO dispersal, monitoring efforts are expected to be less in the Columbia River Estuary.

Outside the Columbia River Estuary, monitoring would be the same as Phase I of Alternative B. Annual aerial abundance surveys would be conducted in priority coastal areas in Washington, Oregon, and the Columbia River Basin above Bonneville Dam during the peak breeding season. Monitoring frequency could change, depending upon DCCO response and information needs (see Table 2-4 under Alternative B).

The Corps would initially undertake the 4-year lethal strategy, which includes annual take of 20.3 percent of the breeding individuals per year, or approximately 5,230, 4,270, 3,533, and 2,923 DCCOs in years 1 to 4, respectively. The 4-year lethal strategy could be adjusted to a 3- or 2-year strategy by increasing take levels after the first year of lethal management. Take percentage in year 2 and 3 could be increased to 28.8 percent for the adjusted 3-year strategy

(6,071 and 4,489 DCCOs taken in year 2 and 3) or 48.0 percent for the adjusted 2-year strategy (10,156 DCCOs taken in year 2; Table 2-5). The Corps would submit an annual depredation permit application to the USFWS for the proposed individual take levels and associated nest loss from take of those individuals. The benefits of a shorter lethal take strategy would be less overall adverse effects from management activities to the DCCO colony and other species on East Sand Island and reduced implementation costs.

The thresholds for adjusting year strategies would be based upon the first year's culling efficiency (i.e., the number of DCCOs lethally taken per day of culling and the total number of days from the first to last culling session) and if the frequency that culling took place did not exceed the lower dispersal threshold (i.e., observed abundance is 70 percent or less than the expected abundance one week after a culling event; Table 2-6). The adjusted 3-year or 2-year could be selected if the proposed take levels for the respective strategy are expected to be achieved by June 26 (i.e., approximate mid-point of when active nests are typically present on East Sand Island [March 27–July 25; see Table 2-5]) and the frequency of culling to achieve the proposed take levels would not exceed the lower dispersal threshold. For example, if 5,230 DCCOs were lethally taken in year 1 in 10 days of culling within a 30 day date range from April 1 to 30, 523 DCCOs (5,230/10) would have been taken per day of culling, or approximately 174 (5,230/30) DCCOs per day during the date range culling took place. With this culling efficiency, the proposed take levels under the adjusted 3-year and 2-year strategy would likely require a culling date range of 35 (6,067/174) and 58 (10,156/174) days, respectively, assuming the same culling frequency would occur (culling 33% of the days during the date range culling took place) and this culling frequency would not exceed the lower dispersal threshold. If this level of take could likely occur by June 26, the Corps, in consultation with the Adaptive Management Team, would then consider adjusting year strategies. Selecting this date (June 26) as a measure for adjusting future year's proposed take levels would be contingent upon implementation occurring as planned.

The proposed take levels in Table 2-5 would be followed by the Corps for requesting take levels in an annual depredation permit application. Lethal take within a given year would cease once annual take levels, authorized in an annual depredation permit, are achieved, or the target colony size, based on peak annual abundance, is achieved. The proposed take levels could be adjusted if the peak observed annual colony size during late incubation deviates from predicted annual colony size (see Appendix E-2) greater than what is expected due to natural annual variation in colony size. Annual variation in colony size is expected. During 2004 to 2013, the average percentage change in colony size between consecutive years was 11 percent; the greatest percent change was 21 percent between 2012 and 2013 (see Figure 1-2). The take levels proposed under all year strategies could decrease if peak observed annual colony size during late incubation, accounting for expected annual variation, becomes lower than model predicted colony size. If peak observed colony size becomes greater than model predicted colony size, additional NEPA review and supporting analyses would be required for increased take levels greater than those proposed and analyzed in the EIS. Any adjustment to year strategies or proposed take levels would occur in coordination with the Adaptive Management Team.

On- and off-colony take efforts (i.e., type, frequency, and duration) and other non-lethal methods would be adjusted depending on effectiveness of technique and resulting dispersal levels in comparison to the identified dispersal threshold (i.e., observed abundance is 70% or less than the expected abundance one week after a culling event; Table 2-6). Management actions would be adjusted to avoid DCCO dispersal. A large disparity between the reduction in colony abundance and the known number of individuals taken accompanied with increased DCCO abundance in the Columbia River Estuary upstream of the typical known foraging range of DCCOs from East Sand Island (i.e., 25 km; Anderson et al. 2004a) or in other monitored areas outside the Columbia River Estuary would be suggestive of increased DCCO dispersal from East Sand Island. Lethal take would decrease, temporarily cease, or techniques would be modified if this occurs. Lethal take would resume when DCCO abundance on East Sand Island returns to greater than 90 percent of the expected abundance and hazing efforts in the estuary are sufficient to adequately deter the number DCCOs present from foraging in upriver locations (Table 2-6).

TABLE 2-6. Lethal Methods and Adaptive Response.

Action[1]	When Used	Monitoring Effort	Adaptive Response
Culling Off-Island	DCCO foraging in the estuary (over water) within 25 km of East Sand Island	Boat-based surveys, field crew observations	If DCCO become wary to shooting off-island from associated disturbance and noise, culling off-island could change locations within the foraging area (25km) to increase effectiveness. Take would occur primarily on-island if off-island culling is ineffective.
Culling On-Island	DCCO present on island (prior to and during nesting season)	Field crew observations, aerial surveys	If observed abundance is 70 percent or less than the expected abundance one week after a culling event, management actions could be changed or scaled back until abundance returns to at least 90% of the expected abundance. Initially, culling would be attempted as early in the year as possible, but, if the lower dispersal threshold (70 percent or less than expected abundance one week after a culling event) is exceeded, culling would not occur until DCCO are observed building and attending active nests (late April). Changes in management actions to reduce dispersal so as not to exceed the lower dispersal threshold (70 percent or

Action[1]	When Used	Monitoring Effort	Adaptive Response
			less than expected abundance one week after a culling event) include: Conduct culling primarily or only at night Use of silencers and sub-sonic shot primarily or only Increase amount of privacy fence Decrease frequency and intensity of culling The Corps would initially undertake the 4-year lethal strategy. The adjusted 3-year or 2-year could be selected if the proposed take levels for the respective strategy are expected to be achieved by June 26 (pending implementation) and the frequency of culling to achieve the proposed take levels would not exceed the lower dispersal threshold (70 percent or less than expected abundance one week after a culling event). Take percentage in year 2 and 3 could be increased to 28.8 percent for the adjusted 3-year strategy (6,071 and 4,489 DCCOs taken in year 2 and 3) or 48.0 percent for the adjusted 2-year strategy (10,156 DCCOs taken in year 2). Proposed individual take levels would include and account for the associated amount of indirect nest loss that could occur from taking the proposed number of individuals. The take levels proposed under all year strategies could decrease if peak observed annual colony size during late incubation, accounting for expected annual variation, becomes lower than model predicted colony size. If peak observed colony size becomes greater than model predicted colony size, additional NEPA review and supporting analyses would be required for increased take levels greater than those proposed and analyzed in the EIS. Any adjustment to year strategies or proposed take levels would occur in coordination with the Adaptive Management Team. Other lethal techniques identified and described in Chapter 2 section 1.2 (i.e., egg addling/destruction/oiling, traps/nets or capture techniques, and euthanasia) could be used depending on knowledge gained during implementation, and review through the Adaptive Management Team. Use of these techniques could require additional NEPA review.

[1]Additional actions such as hazing and habitat modification would be similar to Alternative B Phase I (Table 2-4).

Phase II - Management Actions to Ensure Colony Size Goals are Retained

The same non-lethal methods described in Phase II of Alternative B (i.e., terrain modification, human hazing with use of visual and noise deterrents, and other temporary habitat modifications, as necessary) supported with limited egg take (up to 750 eggs total; 500 on East Sand Island and 250 for other locations in the Columbia River Estuary) would be used to ensure that the target colony size is not exceeded through. Monitoring in the Columbia River Estuary and Adaptive Management would be the same as Phase II of Alternative B.

2.2.4 Alternative D – Culling with Exclusion of DCCO Nesting on East Sand Island in Phase II

Phase I - Management Actions to Reduce Colony Size on East Sand Island and Deter Nesting and Foraging in Columbia River Estuary

Under Alternative D, the same methods described in Alternative C would be used to reduce the DCCO colony on East Sand Island to 5,380–5,939 breeding pairs during Phase I.

Phase II - Management Actions to Exclude all DCCO Nesting on East Sand Island

The same non-lethal methods supported with limited egg take (up to 750 eggs; 500 on East Sand Island and 250 for other locations in the Columbia River Estuary) as described in Phase II of Alternatives B and C would be used to remove all DCCO nesting on East Sand Island and to disperse the remaining approximate 5,600 breeding pairs away from the Columbia River Estuary. Since a large number of DCCOs would be dispersed from East Sand Island in Phase II, monitoring efforts and hazing efforts in the Columbia River Estuary would be similar to those described in Phase I of Alternative B. Costs and efforts could be higher in the short-term because greater effort could be needed to completely exclude DCCOs from nesting on East Sand Island and redistribute them outside the Columbia River Estuary, compared to just ensuring that the Phase I target colony size is not exceeded. Cost and effort would be low or negligible thereafter in the long-term since few or no DCCOs would be present on East Sand Island and in the Columbia River Estuary.

Monitoring and Adaptive Management

Monitoring and adaptive management would initially be the same as Phase I of Alternative B. Monitoring and adaptive management would transition to Phase II of Alternatives B and C after DCCOs are excluded from East Sand Island.

2.3 Alternatives Considered but Eliminated from Detailed Study

In an EIS, federal agencies are required to evaluate a full range of reasonable alternatives that meet the purpose and need for action. These alternatives may be outside the specific authority for a particular federal agency (40 CFR 1502.14(c)) as long as they meet the purpose and need. During the scoping process, the public offered many different solutions (see Chapter 1, section 1.5). The alternatives described below were considered but eliminated from detailed study because they do not meet the purpose and need for the following reasons.

1) Employ Social Attraction Techniques Outside of the Columbia River Estuary to Redistribute DCCOs

As stated in Section 1.1.6, social attraction techniques have been tested within and outside the Columbia River Estuary for several years as a possible method to redistribute the DCCO colony on East Sand Island. Social attraction was unsuccessful in encouraging DCCOs to colonize new sites outside of the Columbia River Estuary. Some success was noted within the Columbia River Estuary at locations where DCCOs have nested or roosted previously, but are known to have a higher per capita impact on juvenile salmonids than DCCOs nesting at East Sand Island (Collis et al. 2002). DCCO social attraction methods have also proved rather unsuccessful at relocating a DCCO colony on a new span of the Old Bay Bridge in San Francisco, including $709,000 spent on alternative nesting platforms (Matier and Ross 2014). Because social attraction was not shown to be a successful method for relocating DCCOs outside of the estuary, and because it therefore would not be effective at meeting the purpose and need, this method was considered, but was eliminated from detailed study. In addition, there are concerns over dispersal and redistribution of DCCOs. New or current colonies increasing in size in Oregon and Washington could impact other sensitive fish species (see Chapter 4).

2) Altering Flow Management Practices

Several alternative suggestions to change flow management practices were made during scoping. One suggestion was in altering flows by increasing the amount of spill at Columbia River dams as a means to inundate East Sand Island. Increasing spill, however, would not achieve any measurable increase in river flows. To inundate East Sand Island, water would need to be released from storage reservoirs; therefore, this alternative is not feasible and would not meet the purpose and need. However, the concept of inundating East Sand Island is reflected in the proposed terrain modification described in Section 2.2.

The other suggestion would be to hold more water in storage as a means to decrease river flows allowing for more marine forage fish to be present in the Lower Columbia River Estuary, and, therefore, available as prey for DCCOs. This method was considered, but was eliminated from detailed study because altering river flow to this extent is not possible as described above and would not meet the stated purpose and need.

3) Altering Fishery Management Practices

This alternative would change or stagger the timing of releases of juvenile salmon to prevent large concentrations of juvenile salmonids migrating through the Lower Columbia River Estuary in April and May, which coincides with the arrival and nest initiation of DCCOs on East Sand Island. This suggestion was proposed during scoping and identified as a method in the Pacific Flyway Council DCCO management plan (Pacific Flyway Council 2012).

The Corps and cooperating agencies worked with ODFW hatchery managers in the Lower Columbia River Estuary (Big Creek) and with USFWS for the Spring Creek National Fish Hatchery to determine feasibility. While there was interest in this alternative from the respective agencies, several issues were identified that indicated this method would not be feasible on a scale large enough to substantially reduce DCCO predation of juvenile salmonids.

The primary concern was operational constraints of individual hatcheries in holding fish for longer periods or releasing them earlier or later in the year. Releasing fish later would require pulling more flow from nearby rivers to maintain adequate water quality and temperatures. In some instances, the required flow necessary to maintain adequate fish rearing conditions would likely exceed the expected flow (e.g., Big Creek). Releasing fish earlier may not be feasible because the juvenile fish may not be of a sufficient age, size, or physiological condition for successful out-migration. Further, spill over Bonneville Dam would be required for an early release of juvenile fish from Spring Creek National Fish Hatchery. Currently, juvenile fish are not released from Spring Creek National Fish Hatchery until the onset of voluntary spill for downstream fish passage at Bonneville Dam on or about April 10. Due to operational constraints of the hatcheries and the lack of feasibility in changing release times on a scale that would effect a measurable change, this method was considered but eliminated from further analysis.

4) Barging Juvenile Salmonids

This alternative, proposed during scoping, suggested barging and releasing salmonids to the Lower Columbia River Estuary in lieu of managing DCCOs and summarized a three-year study titled *Alternative Barging Strategies to Improve Survival of Transported Juvenile Salmonids* (McMichael et al. 2006, also see Marsh et al. 2011), which analyzed recovery rates of PIT tags from wild and hatchery released salmonids from two barge release sites: one at Skamania Landing near Bonneville Dam and the other near Astoria, Oregon.

Barging of juvenile salmonids around the FCRPS has been used as a management strategy to reduce dam and reservoir mortality rates in the Columbia River Basin for decades. Data from Marsh et al. (2011) indicates that extending the release site of barged fish from RM 139 in the tailrace of Bonneville Dam to RM 6 in the Lower Columbia River Estuary reduces smolt predation by Caspian terns and DCCOs nesting on East Sand Island by approximately 60 to 80 percent, compared with smolts released from barges below Bonneville Dam.

However, the barge strategy applies only to the proportion of each salmonid population that can be collected at upstream hydroelectric dams, which are predominately dams on the lower Snake River (FPC 2013). Of the fifteen ESA-listed fish populations that utilize the Columbia River Estuary and are susceptible to DCCO predation, extended barging could potentially only benefit up to seven ESUs and DPSs. Of these seven, under current mandated spill and river operational strategies, roughly 5 to 50 percent (depending on the ESU or DPS and year) are annually loaded into barges and transported to RM 139 (FPC 2013). Numerically, barged fish make up the minority (typically less than 10 percent) of all smolts that pass through the Columbia River Estuary (Dey 2012). Barging only benefits a very small fraction of juvenile salmonids. Thus, this alternative was considered but eliminated from detailed study because it does not meet the purpose and need.

5) Implement a Hunting Season

This alternative, proposed during scoping, suggested a hunting season be established for DCCOs. While the MBTA (16 U.S.C. 703-712) grants the authority to establish hunting seasons for migratory game bird species, only species defined as "game birds" may be considered for hunting. The migratory bird conventions with Canada and Mexico define "game birds" as those species belonging to the following families: Anatidae (swans, geese, and ducks), Rallidae (rails, gallinules, and coots), Gruidae (cranes), Charadriidae (plovers and lapwings), Haematopodidae (oystercatchers), Recurvirostridae (stilts and avocets), Scolopacidae (sandpipers, phalaropes, and allies), and Columbidae (pigeons and doves). DCCOs belong to the family Phalacrocoracidae and are not considered “game birds.” This alternative was considered but eliminated from further analysis because it is inconsistent with the conventions governing the MBTA.

6) Introducing Predators on East Sand Island

Several comments from scoping suggested introducing predators on East Sand Island to manage the DCCO colony. This method was also identified as a method in the Pacific Flyway Council DCCO management plan (Pacific Flyway Council 2012). This method was considered but eliminated from detailed study due to the potential to affect non-target species on East Sand Island, and because there are other more efficient and humane methods for take. Also, there are concerns about dispersal if mammalian predators make the area unsuitable for nesting.

7) A Non-Lethal Only Management Program

Given the magnitude of the colony size reduction and realities of field logistics, it is not feasible to advance an alternative that relies solely on non-lethal methods. Some minimal level of egg take would likely have to occur under every alternative for effective implementation, even when using best management practices. This is based on prior field experience during the dissuasion research. Given this, a non-lethal only management program was considered but dismissed from detailed study because it would not feasibly meet the purpose and need.

8) A Lethal Only Management Program

An alternative that considered lethal only management was not considered for detailed study because a lethal only management program would not be feasible and take of a species protected under the MBTA requires authorization under a depredation permit, which specify use and integration of non-lethal techniques. Since 2008, the Corps has conducted research on East Sand Island, which has focused on use and assessment of non-lethal techniques. Use and effectiveness of some of these non-lethal techniques to haze DCCO have been demonstrated and documented, while others have not been effective. Effective non-lethal techniques have been incorporated into the EIS alternatives. Phase II of the EIS alternatives proposes methods that transition to non-lethal techniques that reduce the amount of human presence needed on the island, which would not be feasible under a lethal only management program. Additionally, hazing is inherent to some lethal take methods (e.g., shooting from boats can scare more birds away from a location than can be lethally removed) and a non-lethal hazing management component would be necessary to deter DCCOs from nesting in the Columbia River Estuary, as lethal take would likely not be permissible in as many areas as non-lethal methods. Lastly, Federal Migratory Bird Depredation permit applications state: "You should apply for a depredation permit only after non-lethal management proves unsuccessful. If a permit is issued, you will be expected to continue to integrate non-lethal techniques when implementing any lethal measures." The standard conditions issued for Federal Migratory Bird Depredation permits state: "To minimize the lethal take of migratory birds, you are required to continually apply non-lethal methods of harassment in conjunction with lethal control."

9) A Take of Individuals as Primary Method Alternative

An alternative was considered that included take of individuals as the primary method, with limited (up to 250) eggs collected during the nesting season. This alternative was dismissed from detailed study because it does not meet the purpose and need due to feasibility concerns over timing of activities during the breeding season, given the magnitude of the colony reduction being considered. This alternative would require essentially all take of individuals to be completed prior to DCCOs attending active nests. This timing constraint could effectively eliminate the ability to implement the scale of reduction necessary to achieve the target size. Given the regulatory definition of take under the MBTA, any activity that leads to take of a breeding bird attending an active nest effectively takes the eggs and nest of that breeding bird. The lethal take strategy described in Alternatives C and D, in which take of individuals is the primary method but indirect take of eggs and nests are included into the proposed take levels, was determined to be more feasible in meeting the objectives of the purpose and need.

10) Egg Take Only to Reduce the Colony Size

This alternative would have utilized egg take as the sole lethal method to reduce the East Sand Island colony. Of the life stages on which lethal take could occur, take of individuals was determined to be the most feasible approach to achieving the target colony size by the end of the 2018 timeframe of the 2014 FCRPS Biological Opinion (NOAA 2014) because DCCOs typically breed in their third year (Hatch and Weseloh 1999) and there would be a multiple year delay before decreased recruitment begins to affect the colony size (see Appendix E). This alternative was eliminated from detailed study because it would not meet the purpose and need by the end of the 2018 timeframe of the 2014 FCRPS Biological Opinion (NOAA 2014).

11) A Lesser Degree of Lethal Take (Individual or Egg Take)

Alternatives proposing a lesser amount of take were not considered for detailed study because they would not meet NOAA Fisheries goals to avoid jeopardy by the end of the 2018 timeframe of the 2014 FCRPS Biological Opinion (NOAA 2014).

13) A Greater Degree of Lethal Take (Individual or Egg Take)

Alternatives proposing a greater amount of take were not considered for detailed study because additional lethal take would be in excess of specified targets identified in RPA 46 of the 2014 FCRPS Biological Opinion. Additionally, greater levels of take could increase the risk of affecting the long-term conservation of the western population of DCCOs.

2.4 Comparison of Alternatives

The following summary tables provide a comparison of Alternatives A–D, carried forward for detailed study. Table 2-7 presents the alternatives and outlines specific actions occurring under each alternative. Table 2-8 presents an estimate of dollar costs to implement each alternative.

TABLE 2-7. Comparison of Alternatives.

		Alternative A	Alternative B	Alternative C *(Preferred Alternative/ Management Plan)*	Alternative D
Location and Action		**No Action**	**Non-Lethal Management Focus with Limited Egg Take**	**Culling with Integrated Non-Lethal Methods Including Limited Egg Take**	**Culling with Exclusion of DCCO Nesting on East Sand Island in Phase II**
EAST SAND ISLAND	Hazing	No	Yes - Human presence, visual and noise deterrents used to dissuade DCCO from nesting outside of designated area. Extensive in Phase I. Supplementary in Phase II to maintain target colony size.	Yes - Same methods, but less intensive than Alternative B in Phase I. Identical to Alternative B in Phase II.	Yes - Same methods as Alternative C. Greater effort than Alternative B in Phase II in order to dissuade 100 percent of DCCOs from East Sand Island.
	Habitat Modification	No	Yes - Temporary techniques (fences, barriers, etc.) used during Phase I to incrementally restrict DCCOs to nest in designated area. Terrain modification techniques (excavating sand, creating berms) initiated in Phase I, if necessary. In Phase II, terrain modification would be used to maintain colony size; supplementary temporary techniques used, if needed.	Yes - Same methods, but less intensive than Alternative B in Phase I. Same as Alternative B in Phase II.	Yes - same methods as Alternative C. Greater effort than Alternative B in Phase II in order to dissuade 100 percent of DCCOs from East Sand Island.
	Take of Individuals	No	No	Yes - Primary method is take of individuals under a 4-year lethal take strategy. Each year, 20.3 percent of the DCCO colony would be culled; 15,955 DCCOs in all years (5,230, 4,270, 3,533, and 2,923 DCCOs in years 1 to 4, respectively). Take rates could be increased to 3- or 2-year strategy. Take percentage in year 2 and 3 could be increased to 28.8 percent for the adjusted 3-year strategy (6,071 and 4,489 DCCOs taken in year 2 and 3) or 48.0 percent for the adjusted 2-year strategy (10,156 DCCOs taken in year 2). Proposed individual take levels would include and account for the associated amount of indirect nest loss that could occur from taking the proposed number of individuals. In Phase II, take of individuals would not occur.	Yes - Same as Alternative C.
	Take of Eggs/Nests	No	Yes - Limited amount of egg take necessary to implement the primary management action; take of 500 eggs would be requested in a depredation permit application the first year and would be adjusted accordingly thereafter.	Yes - In Phase I, egg take is not primary lethal method, but would occur in support of non-lethal techniques (up to 500 eggs) and indirectly from loss of associated nests when individuals are taken. In Phase II, egg take could occur in support of non-lethal techniques (up to 500 eggs).	Yes - Same as Alternative C

		Alternative A	Alternative B	Alternative C *(Preferred Alternative/ Management Plan)*	Alternative D
Location and Action		**No Action**	**Non-Lethal Management Focus with Limited Egg Take**	**Culling with Integrated Non-Lethal Methods Including Limited Egg Take**	**Culling with Exclusion of DCCO Nesting on East Sand Island in Phase II**
EAST SAND ISLAND	Monitoring	No	Yes - In Phase I, monthly aerial counts and counts by field crews to determine colony abundance and nesting density and productivity; PIT tag recoveries after the breeding season to assess predation. DCCO counts, behavior, and response of non-target species to determine impacts and effectiveness of management actions. Abundance counts method to assess dispersal. In Phase II, same monitoring as Phase I, as necessary. An average 3-year peak breeding season colony size estimate would be used to evaluate actual colony size to target size.	Yes - Same as Alternative B in Phase I, except no individual marking in adaptive management. Same as Alternative B in Phase II.	Yes - Same as Alternative C in Phase I. In Phase II, same as Phase I of Alternative B. All monitoring would cease in Phase II, once DCCOs are no longer present on East Sand Island.
Columbia River Estuary	Monitoring	No	Yes - In Phase I, extensive aerial, boat, and land surveys to monitor DCCO abundance throughout the entire Columbia River Estuary during the breeding season; 5-8 boat crews monitoring some areas daily or weekly. In Phase II, DCCO abundance surveys conducted as needed, depending on future information needs, but extensive effort still likely required.	Yes - In Phase I, same methods as Alternative B but much less effort required. Surveys conducted to monitor DCCO abundance at priority areas and east of typical DCCO foraging range (25km) from East Sand Island. <5 boat crews; surveys 2-3 days following a culling session and would decrease in frequency, as necessary, ultimately to monthly aerial surveys only. In Phase II, same as Alternative B, but less effort likely needed.	Yes - Same as Alternative C for Phase I. In Phase II, same as Phase I of Alternative B.
	Hazing	No	Yes - In Phase I, adaptive hazing plan and non-lethal techniques would be used to deter DCCOs from nesting in any areas once hazing triggers are met (i.e., DCCO breeding behavior observed, >50 DCCOs loafing; DCCOs present at twilight). Extensive boat-based hazing would be used to prevent DCCO foraging. Take of 250 eggs on Corps' dredged material sites would be requested in a depredation permit application the first year and adjusted accordingly thereafter. In Phase II, a long-term, extensive effort would likely be needed to keep DCCOs from nesting at other areas. Same adaptive hazing plan, hazing triggers, and non-lethal techniques as Phase I.	Yes - Same as Alternative B, but much less effort required.	Yes - Same as Alternative C in Phase I. In Phase II, same as Phase I of Alternative B.

		Alternative A	Alternative B	Alternative C *(Preferred Alternative/ Management Plan)*	Alternative D
Location and Action		**No Action**	**Non-Lethal Management Focus with Limited Egg Take**	**Culling with Integrated Non-Lethal Methods Including Limited Egg Take**	**Culling with Exclusion of DCCO Nesting on East Sand Island in Phase II**
Outside Columbia River Estuary	Monitoring	No	Yes - In Phase I, priority coastal areas in Washington, Oregon, and Columbia River Basin above the Bonneville Dam would be monitored at least once during the peak breeding season for DCCO abundance. In Phase II, monitoring would match or supplement the Pacific Flyway Council monitoring strategy for the western population of DCCOs, which calls for surveys at a sample of historic and current colonies every three years. Survey frequency in Phase I and II could change to three surveys per year based on information needs.	Yes - Same as Alternative B in Phase I and II.	Yes - Same as Alternative B in Phase I and II.

TABLE 2-8. Annual Cost Comparison of Action Alternatives.

PHASE I	Alternative B Non-Lethal Management Focus with Limited Egg Take	Alternative C *(Preferred Alternative/ Management Plan)* Culling with Integrated Non-lethal Methods Including Limited Egg Take	Alternative D Culling with Exclusion of DCCO Nesting in Phase II
Ground Efforts to Reduce Habitat and Colony Size (includes monitoring field crew costs)	$200,000 to $300,000 (depends on # of crews, # of days and transport of materials)	$400,000 to $500,000 (depends on # of crews, # of days, and transport of materials)	Same as Alternative C
Monitoring East Sand and Columbia River Estuary	$200,000 to $300,000 (depends on frequency of surveys and dispersal; more surveys are expected in estuary)	$100,000 to $125,000 (depends on frequency of surveys and dispersal; more surveys are expected in estuary)	Same as Alternative C
Hazing DCCOs from Moving to Columbia River Estuary	$400,000 to $500,000 (depends on dispersal of DCCO)	$10,000 to $20,000 (depends on dispersal, which is expected to be less)	Same as Alternative C
Monitoring outside of Columbia River Estuary	$100,000 to $125,000 (depends on number of surveys and photo analysis, increases in frequency)	$50,000 to $75,000 (depends on number of surveys and photo analysis)	Same as Alternative C
PIT tag Recovery	$200,000 to $300,000 (depending on access and analysis)	Same as Alternative B	Same as Alternative B
Total Costs Per Year Phase I	**$1,100,000-$1,525,000 (annual)**	**$ 760,000 - $1,020,000 (annual)**	**$ 760,000 - $1,020,000 (annual)**
PHASE II			
Terrain Modification	$5,000,000 to $7,000,000 (depends on quantities excavated and location of disposal area)	Same as Alternative B	Same as Alternative B
Efforts to Retain Colony Size Goals on East Sand Island	$200,000 to $300,000 (depends on persistence of DCCO in using East Sand Island)	$75,000 to $100,000 (depends on persistence of DCCO)	Same as Alternative B
Monitoring and Hazing in Columbia River Estuary	$100,000 to $125,000 (depends on number of surveys and photo analysis, increases in frequency expected)	$100,000 to $125,000 (depends on frequency of surveys and dispersal; more surveys are expected in estuary)	$400,000 to $500,000 (depends on dispersal of DCCO and where hazing is needed)
Monitoring Western Population	$75,000 to $85,000	Same as Alternative B	Same as Alternative B
PIT tag Recovery	$200,000 to $300,000	Same as Alternative B	Same as Alternative B
Total Costs Per Year Phase II (w/out terrain modification)	**$500,000-$725,000 (annual) + $75,000-$85,000 every three years***	**$375,000-$525,000 annual + $75,000-$85,000 every three years**	**$800,000-$1,100,000 annual + $75,000-$85,000 every three years**

*monitoring western population in Phase II would occur every three years.

2.5 Relationships to Federal, State, and Local Policies and Plans

This section describes regional plans relevant to DCCOs and salmon conservation efforts and addresses consistency with waterbird conservation efforts. The intent of this section is to identify possible conflicts between the proposed alternatives and the objectives of federal, regional, state, and local land use plans in the area concerned (40 CFR 1502.16(c)). Many salmon recovery efforts are identified in regional (i.e., Pacific Fisheries Management Council's Pacific Coast Salmon Fishery Management Plan), tribal (Columbia River Inter-Tribal Fish Commission's Wy-Kan-Ush-Mi Wa-Kish-Wit), and state agency plans. The proposed actions in the alternatives described in Section 2.2 are consistent with the general overall objectives of improving salmon and steelhead runs in the Columbia River Basin.

Pacific Flyway Council

The Pacific Flyway Council is an administrative body that forges cooperation among federal and Pacific Flyway state wildlife agencies for the purpose of managing and conserving migratory birds. In 2010, the Pacific Flyway Council began development of a DCCO management framework and monitoring strategy in anticipation of current and future management needs. In July 2012, the Pacific Flyway Council finalized *A Framework for the Management of Double-crested Cormorants Predation on Fish Resources in the Pacific Flyway.* This document provides a framework for management of the western population of DCCOs and guidelines to follow when addressing DCCO-fish conflicts in the Pacific Flyway. The plan is available at: http://pacificflyway.gov/Abstracts.asp#dcc.

To the extent practicable, the proposed alternatives are consistent with the Pacific Flyway Council plan in the following ways: there is empirical evidence documenting DCCO predation of juvenile salmonids; non-lethal measures were conducted as part of dissuasion research and are built into the alternatives; actions comply with Federal, state, and local regulations; benefits to juvenile salmonids and effects to DCCOs and other non-target species and resources have been analyzed by the respective federal resource agencies; and expected outcomes of management are identified in the alternatives section and environmental consequences section (Chapter 4).

In March 2013, the Pacific Flyway Council published *A Monitoring Strategy for the Western Population of Double-crested Cormorants within the Pacific Flyway*. The objective of this plan is to detect a 5 percent annual change in the number of breeding pairs in the western population of DCCOs. Monitoring is conducted by the Pacific Flyway state wildlife agencies, the USFWS, and other entities. Beginning in 2014, randomly selected historic and active colony locations would be monitored every 3 years for at least 10 years. Proposed monitoring in the EIS for East Sand Island, the Columbia River Estuary, and coastal regions of Oregon and Washington is more intensive than what is specified in the Pacific Flyway Council monitoring strategy. Efforts would be made to coincide protocols and monitoring effort, where and when possible. DCCO response to management on East Sand Island and future information needs would dictate the extent to which this is practicable. The plan is available at: http://pacificflyway.gov/Documents/Dcc_strategy.pdf.

Pacific Region Waterbird Conservation Planning and the 2005 Seabird Conservation Plan

Within the Pacific Region, there are several conservation plans related to waterbirds found in the Columbia River Estuary. The 2002 North American Waterbird Conservation Plan (Kushlan et al. 2002) provides an overarching plan and framework for conserving waterbirds. In that plan, species of conservation concern were identified. The 2005 USFWS Seabird Conservation Plan (USFWS 2005b) was developed to identify USFWS priorities for seabird conservation. The plan specifically identifies East Sand Island as being important for Caspian terns and DCCOs.

Many of the bird species mentioned in this document are included in the Seabird Conservation Plan, which identifies species-specific conservation recommendations. Conservation recommendations for DCCOs included: researching predation on fish resources, monitoring contaminants, protecting nest sites, and conducting a range-wide survey. DCCOs are considered “not currently at risk” on both the North American Waterbird Conservation Plan and the USFWS Seabird Conservation Plan for the Pacific Region (USFWS 2005b).

As a cooperating agency, the USFWS has input in developing this EIS, specifically the analysis of effects to birds under their jurisdiction and in ensuring the proposed alternatives and scope of analysis are sufficient and consistent with their regional plans. The 2005 Seabird Conservation Plan can be read in detail at:
http://www.fws.gov/pacific/migratorybirds/PDF/Seabird%20Conservation%20Plan%20Complete.pdf.
The 2002 North American Waterbird Conservation Plan is available at:
http://www.waterbirdconservation.org/pdfs/plan_files/complete.pdf.

Salmon and Steelhead Recovery Plans

NOAA Fisheries has adopted nine recovery plans for salmon and steelhead. Recovery plans for Snake River Basin species, Oregon Coast coho salmon, and several California salmon and steelhead species are under development at the time of this EIS. Avian predation is generally acknowledged as a factor affecting certain listed ESUs/DPSs, though not necessarily a factor contributing to their decline or limiting their recovery. Direct mortality from avian predation (DCCO and Caspian terns) is identified as one of the secondary factors limiting viability for all Lower Columbia River coho and late fall and spring Chinook salmon and steelhead populations; a key limiting factor affecting all Middle Columbia River steelhead populations and Upper Willamette River Chinook and steelhead; and a threat to Upper Columbia River spring Chinook and steelhead populations. Many of the recovery boards and plans support immediate adoption of effective predator control programs, including lethal removal, when necessary, of avian predators that have the most significant negative impacts on ESA-listed salmonids.

NOAA Fisheries recovery plans and supporting documents are available at the following link: http://www.westcoast.fisheries.noaa.gov/protected_species/salmon_steelhead/recovery_planning_and_implementation/recovery_plans_supporting_documents.html.

Oregon Coastal Management Program - Clatsop County Comprehensive Plan

Congress enacted the Coastal Zone Management Act (CZMA) (16 U.S.C. 1451 et seq.) to protect the coastal environment from growing demands associated with development. In accordance with Section 304(a) of the Act, all federal lands, owned, leased, held in trust, or whose use is otherwise subject solely to the discretion of the federal government, are excluded from the coastal zone. However, if the federal agency conducts the action on federal lands and the action does affect coastal uses or resources off of federal lands, then a state may review the action for consistency with the state's enforceable policies.

The state of Oregon has a federally approved coastal management program which defines, through its land use planning process, enforceable policies that apply to activities proposed in a coastal zone. These policies are generally found in the statewide planning goals and the approved city or county comprehensive plan and implementing land use regulations. Federal agencies must follow the federal consistency provisions as delineated in 15 CFR Part 930. East Sand Island is considered federal land for the purposes of the CZMA. However, some management actions would occur off the island. Early coordination with Oregon's CZMA Federal Relations Coordinator concluded the best approach is to submit the final EIS and seek consistency on the preferred alternative.

2.6 Permits and Approvals Needed

The following permits would be required prior to the implementation of proposed alternatives:

MIGRATORY BIRD DEPREDATION PERMITS (Migratory Bird Treaty Act, 50 CFR 21.41). A Federal Migratory Bird Depredation Permit will be required from the USFWS for any management action that involves take (including the preferred alternative), as defined by 50 CFR 10.12. No permit is required to implement non-lethal methods, if there is no potential for take.

SPECIAL USES AUTHORIZATION (Oregon Administrative Rules 141-125-0100). A special uses authorization from the Oregon Department of State Lands may be required prior to implementing some hazing actions on state owned land, however the Corps has easements with the states of Oregon and Washington to dispose of dredged material on many islands in the Columbia River Estuary which are identified as areas of key hazing (Table 2-3) and permits are not expected to be required for those actions under existing easements.

U.S. ARMY CORPS OF ENGINEERS REAL ESTATE AGREEMENT (36 Code of Federal Regulations Part 327). A real estate license/agreement to access and utilize federal land may be required prior to implementing actions on East Sand Island and to close the island to public use during implementation of any of the action alternatives.

OREGON DEPARTMENT OF STATE LANDS PERMIT (Oregon Revised Statute 196.795-990). A permit from the Oregon Department of State Lands may be required for the terrain modification proposed for Phase II, primarily for wetlands that would be filled when disposing of excavated sand on the island. No permit will be required if these areas are avoided.

Chapter 3 Affected Environment

3.1 Introduction

The "affected environment" section of an EIS should "succinctly describe the environment of the area(s) to be affected or created by the alternatives under consideration. The descriptions shall be no longer than is necessary to understand the effects of the alternatives. Data and analyses in a statement shall be commensurate with the importance of the impact, with less important material summarized, consolidated, or simply referenced" (40 CFR 1502.15). Thus, only the biological and socioeconomic resources expected to be potentially impacted by the alternatives under consideration are discussed in this chapter. Biological resources in the affected environment include DCCOs, other bird species, and fish species. For other bird species, primary focus is on other birds that use East Sand Island for nesting or roosting, species that co-nest with DCCOs, and species of conservation concern that could be potentially impacted by DCCOs and actions under the alternatives. For fish species, primary focus is on ESA-listed fish that could be potentially predated by DCCOs. Socioeconomic resources include tribal, commercial, and recreational fisheries, and communities, specifically public health and safety, structures, property and vegetation, and historic properties that are present on East Sand Island.

All of the action alternatives proposed in this EIS are expected to cause some dispersal of DCCOs. Because of this, the affected environment encompasses a large geographic area including the coastal and interior areas from northern California (37°24'00") to southern British Columbia (51°00'00") and the states of Oregon and Washington (Figure 3-1). This scope was developed by the DCCO Interagency Working Group and includes an area that DCCOs, if dissuaded from nesting on East Sand Island, can be expected to prospect for new breeding sites. Nearly all (more than 94 percent) of the documented post-breeding and wintering locations of DCCOs marked on East Sand Island were within this area (BRNW unpublished data; also see Table 3-1 and Courtot et al. 2012).

Actions related to the EIS would likely affect the biological and socioeconomic resources in the Columbia River Estuary and those on East Sand Island more than any other areas within the affected environment. There is high likelihood that DCCOs, if deterred from nesting on East Sand Island, would initially prospect for other nearby nesting sites within the Columbia River Estuary. During efforts to restrict DCCO nesting on East Sand Island during the 2011–2013 breeding seasons, nearly all satellite-

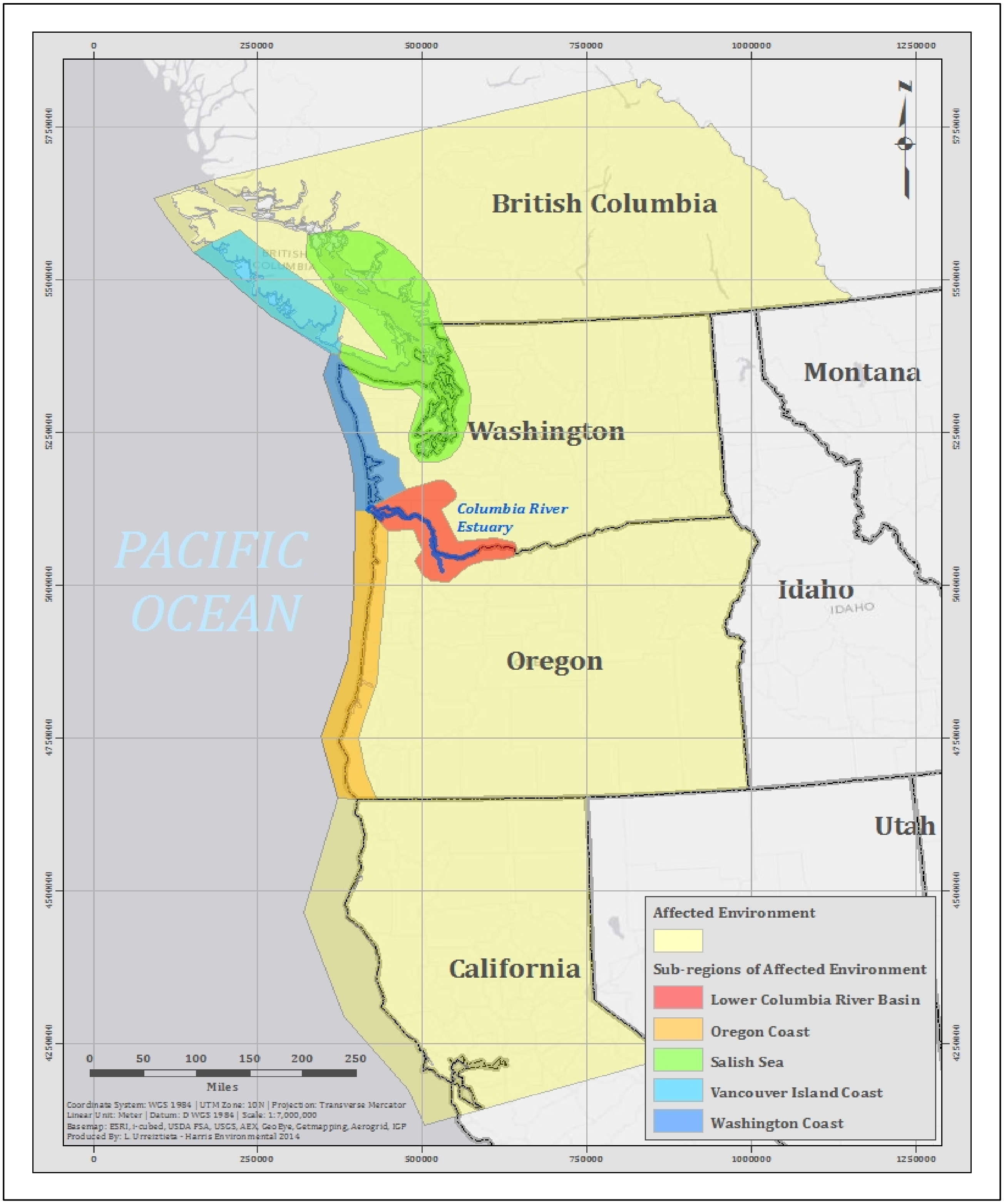


FIGURE 3-1. Map of the affected environment and sub-regions of management concern.

tagged DCCOs relocated to the Astoria-Megler Bridge or other nearby areas to East Sand Island immediately following hazing events, and there was little evidence of permanent emigration from the Columbia River Estuary (Roby et al. 2014).

To better categorize and describe anticipated effects resulting from proposed management alternatives, sub-regions of the affected environment were identified that are more likely to experience use by DCCOs, if dissuaded from East Sand Island. Thus, in Chapters 3 and 4, resources of the sub-regions of the affected environment are described in more detail and given a greater depth of analysis than resources of the affected environment outside of the sub-regions. These sub-regions were based upon knowledge of the species, past research findings, and areas where active and historic DCCO colonies overlap with where DCCO dispersal from East Sand Island has been documented. Disturbance-induced breeding season dispersals of marked East Sand Island DCCOs have been documented extending only into a small portion of the post-breeding and wintering range (Roby et al. 2013, Roby et al. 2014). Areas within the breeding season dispersal range that were more distant from East Sand Island were used much less frequently.

Sub-regions of the affected environment are: 1) Lower Columbia River Basin (including the Columbia River Estuary and lower Willamette River); 2) Washington Coast; 3) Salish Sea (including the Strait of Juan de Fuca, Strait of Georgia, and Puget Sound); 4) Vancouver Island Coast; and 5) Oregon Coast. From DCCOs satellite-tagged on East Sand Island during 2012 and 2013, use during March–September was highest in the Lower Columbia River Basin, followed by the Washington Coast and Salish Sea. Use of the outer Vancouver Island Coast and Oregon coast was minimal (Table 3-1). Resight information during 2010–2013 from DCCOs banded on East Sand Island also shows highest connectivity to the Lower Columbia River Basin, Washington Coast, and Salish Sea (Figure 3-2).

TABLE 3-1. Usage of DCCOs Satellite-tagged on East Sand Island during March 1–September 30 that were Marked Prior to the 2012 and 2013 Nesting Seasons and the Number of Active and Historical DCCO Colonies (from Adkins and Roby 2010) Within the Five Sub-regions of the Affected Environment.

Region	# of Birds that Visited	% of Birds that Visited	# of Detections	% of Detections	Active Colonies	Active + Historical Colonies
Oregon Coast	0	0.0 %	0	0.0 %	22	40
Lower Columbia River Basin	93	97.9 %	976	59.7 %	4	8
Washington Coast	61	64.2 %	460	28.1 %	4	32
Salish Sea	20	21.1 %	144	8.8 %	12	44
Vancouver Island Coast	4	4.2 %	55	3.4 %	0	0

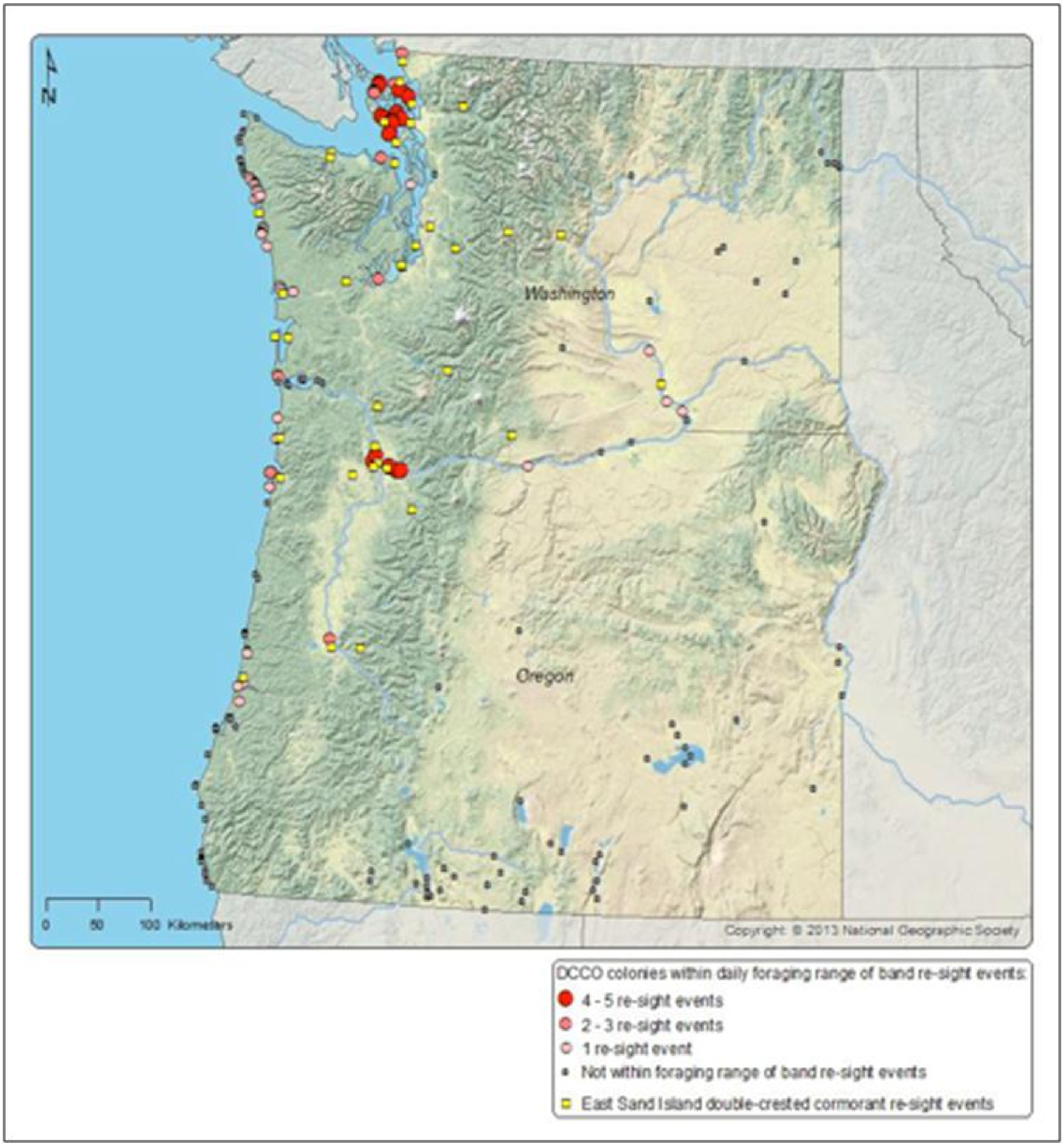


FIGURE 3-2. DCCO colonies in Oregon and Washington visited during 2010-2013 by DCCOs banded on East Sand Island.

3.2 Biological Environment

The affected environment provides significant habitat for both fish and wildlife, and East Sand Island is an important area for migratory birds. Section 3.2.1 describes existing conditions, vegetative communities, soils, and inundation patterns on East Sand Island. Section 3.2.2 describes the life history of DCCOs and gives specific information on DCCO colonies in the affected environment. Section 3.2.3 addresses other colonial waterbirds common to East Sand Island, as they are the most likely to be impacted by the proposed alternatives. Section 3.2.4 addresses other birds within the affected environment that co-nest with DCCOs and/or are of special conservation concern. Section 3.2.5 provides an overview of ESA-listed fish in the affected environment. Section 3.2.6 provides specific information on ESA-listed fish in the Lower Columbia River Basin and provides ESU-specific predation rates based on PIT tag recoveries on East Sand Island. Section 3.2.7 provides information on ESA-listed fish in the affected environment, specifically focusing on listed fish that would be vulnerable to predation by DCCO, should they relocate to other areas in the region.

3.2.1 Vegetation and Soils on East Sand Island

DCCO habitat requirements and usage are described in Chapter 3, section 3.2.2. On East Sand Island, DCCOs nest and use vegetated and bare, open substrate. As DCCOs are known to impact vegetation and soils (see Chapter 3, section 3.3.4), this section describes the general vegetative communities on East Sand Island, indicating which areas DCCOs have typically used on the island.

Vegetation Communities

East Sand Island can be divided into six main vegetation communities based on vegetation type and bird species impacts (Figure 3-3). The percent cover reported here is classified by life forms, including herbaceous plants, shrubs, and trees. Percent cover may total more than 100 percent, due to an area being under the canopy of more than one life form. Only the three most dominant species are reported for each life form, thus, percent cover for all species is greater than what is presented.

FIGURE 3-3. Areas of vegetation communities, based on vegetation communities and impacts by birds on East Sand Island.

The upland area on the western portion of the island, approximately 12 acres in size, was identified as Area 1. This area has been used by DCCOs predominantly for nesting and is mostly devoid of vegetation, with the exception of a few scattered willows and small shrubs. DCCOs were hazed from a portion of this area during the 2013 breeding season, and some vegetation is returning to the area where DCCOs were excluded. The three most dominant herbaceous species accounted for approximately 92 percent of the herbaceous plant canopy cover in Area 1. These included common chickweed (*Stellaria media*) [50 percent], annual bluegrass (*Poa annua*) [40 percent], and bull thistle (*Circium vulgare*) [2 percent]. The three species with the greatest percent cover in the shrub life form were gorse (*Ulex europaeus*) [5 percent], elderberry (*Sambucus racemosa*) [3 percent], and Himalayan blackberry (*Rubus armeniacus*) [<1 percent]. The three dominant trees encountered were Sitka spruce (*Picea sitchensis*) [2 percent], red alder (*Alnus rubra*) [2 percent], and Oregon ash (*Fraxinus latifolia*) [<1 percent].

Adjacent to the primary nesting area, DCCOs have been excluded from Area 2 for the last three breeding seasons (2011-2013). This area is approximately 3 acres in size and represents an intermediary zone between the heavy DCCO nesting area and the more vegetated portion of the central island. Geese have utilized this area throughout the spring and summer of each year that the DCCOs were excluded. The three most dominant herbaceous plant species accounted for approximately 11 percent canopy cover in Area 2. These species included American dunegrass (*Leymus mollis*) [5 percent], common velvetgrass (*Holcus lanatus*) [5 percent], and annual bluegrass [1 percent]. The three shrubs with the greatest percent cover were salmonberry (*Rubus spectabilis*) [5 percent], elderberry [3 percent], and twinberry (*Lonicera involucrata*) [3 percent]. The three dominant trees encountered were Sitka spruce [1 percent], red alder (*Alnus rubra*) [2 percent], and bitter and domesticated cherries (*Prunus* spp.) [<1 percent].

The central portion of the island (Area 3), approximately 3 acres in size, contains silt loam and silty clay loam and has a dense understory of shrubs. The most dominant herbaceous plants and their percent cover in Area 3 are common velvetgrass (*Holcus lanatus*) [10 percent], slough sedge (*Carex obnupta*) [5 percent], and American dunegrass [2 percent]. Shrubs with the greatest percent cover were elderberry [55 percent], salmonberry [30 percent], and twinberry [15 percent]. Trees accounted for approximately 11 percent of the canopy cover of Area 3, and the dominant trees encountered were red alder [10 percent], Sitka spruce [<1 percent], and Pacific crabapple (*Malus fusca*) [<1 percent].

Area 4 is approximately 10 acres in size and is densely covered with a mix of shrub and tree species, including, but not limited to, willows (*Salix spp*.), elderberry, red alder *(Alnus rubra),* and Sitka spruce at the edge of the unit. These areas have not been used for nesting by any of the colonial waterbirds on the island. The most dominant herbaceous species and their percent cover were common velvetgrass (*Holcus lanatus*) [5 percent], common rush (*Juncus effusus*) [2 percent], and woodland buttercup (*Ranunculus uncinatus*) [1 percent]. Shrub cover was 100 percent, with the three dominant species being Hooker willow (*Salix hookeriana*) [55 percent], salmonberry [35 percent], and twinberry [10 percent]. The dominant trees encountered were red alder [2 percent], Sitka spruce [1 percent], and western hemlock (*Tsuga heterophylla*) [<1 percent].

The easternmost area of the island (Area 5) is approximately 17 acres in size and contains the primary nesting sites for the Caspian terns and ring-billed gulls in the upland area. The most dominant species were American dunegrass [40 percent], cheatgrass (*Bromus tectorum*) [10 percent], and common velvetgrass (*Holcus lanatus*) [15 percent]. Shrubs with the greatest percent cover were Hooker willow [5 percent], elderberry [2 percent], and gorse [2 percent]. The dominant trees encountered were red alder [<1 percent], black cottonwood (*Populus balsamifera* ssp. *trichocarpa*) [<1 percent], and Oregon ash [<1 percent]. The managed Caspian tern colony (Area 6) is approximately 1.58 acres, as of February 2014, and has only sparse coverage, including American dunegrass shoots [<1 percent].

Invasive/Noxious Weeds

Observed invasive or noxious weed species are Japanese knotweed (*Polygonum cuspidatum*), gorse (*Ulex europaeus*), Scotch broom (*Cytisus scoparius*), yellow flag iris (*Iris pseudacorus*), Himalayan blackberry (*Rubus armeniacus*), stinking willie (*Senecio jacobaea*), and bull thistle (*Circium vulgare*).

Soils

Due to the history of disturbance and the dynamic nature of the fluvial system, soils on the island are very young and poorly developed. Soils on East Sand Island are mapped in the Clatsop County, Oregon (OR007) Soil Survey as Tropopsamments, 0 to 15 percent slopes (Soil Survey Staff, 2014). These soils have been built up by repeated alluvial deposition, evidenced by the thin contrasting layers in exposed profiles from the northwestern shore of the island. They are very deep, excessively drained, and very low in organic matter and fines (silts and clays). Poorly developed A horizons are typically less than four inches thick on the island and relatively low in organics (mostly partially decomposed sticks, twigs, and recognizable plant material). Soils observable in some beach exposures on the northern and northeastern shore of East Sand Island are higher in silt (predominantly silt loam textures). This is likely the Coquille soil in Map Unit 11A (Fluvaquentic Edoaquepts) that is mapped along the northern and eastern shores of adjacent Sand Island. This soil profile has common redox features throughout, as a result of its proximity to the water table and its higher water holding capacity. This inclusion may be capped with sand and occur as a buried soil further inland, likely perching and retaining water.

Inundation at East Sand Island

The area-time inundation index model (ATIIM, Section 4.5.3) was used to model inundation at East Sand Island. The expected inundation of the island at four water surface elevations is presented in Figure 3-4, to illustrate the range of inundation in the existing terrain condition. The lowest water surface elevation shown, 1.2 m (NAVD88), is equivalent to the current lower boundary of marsh elevation at reference sites in Baker Bay (Borde et al. 2011). The highest water surface elevation shown, 3.0 m, was the maximum water surface elevation reached for the modeled period, March-October 2009 (see Chapter 4, section 4.5.3.2).

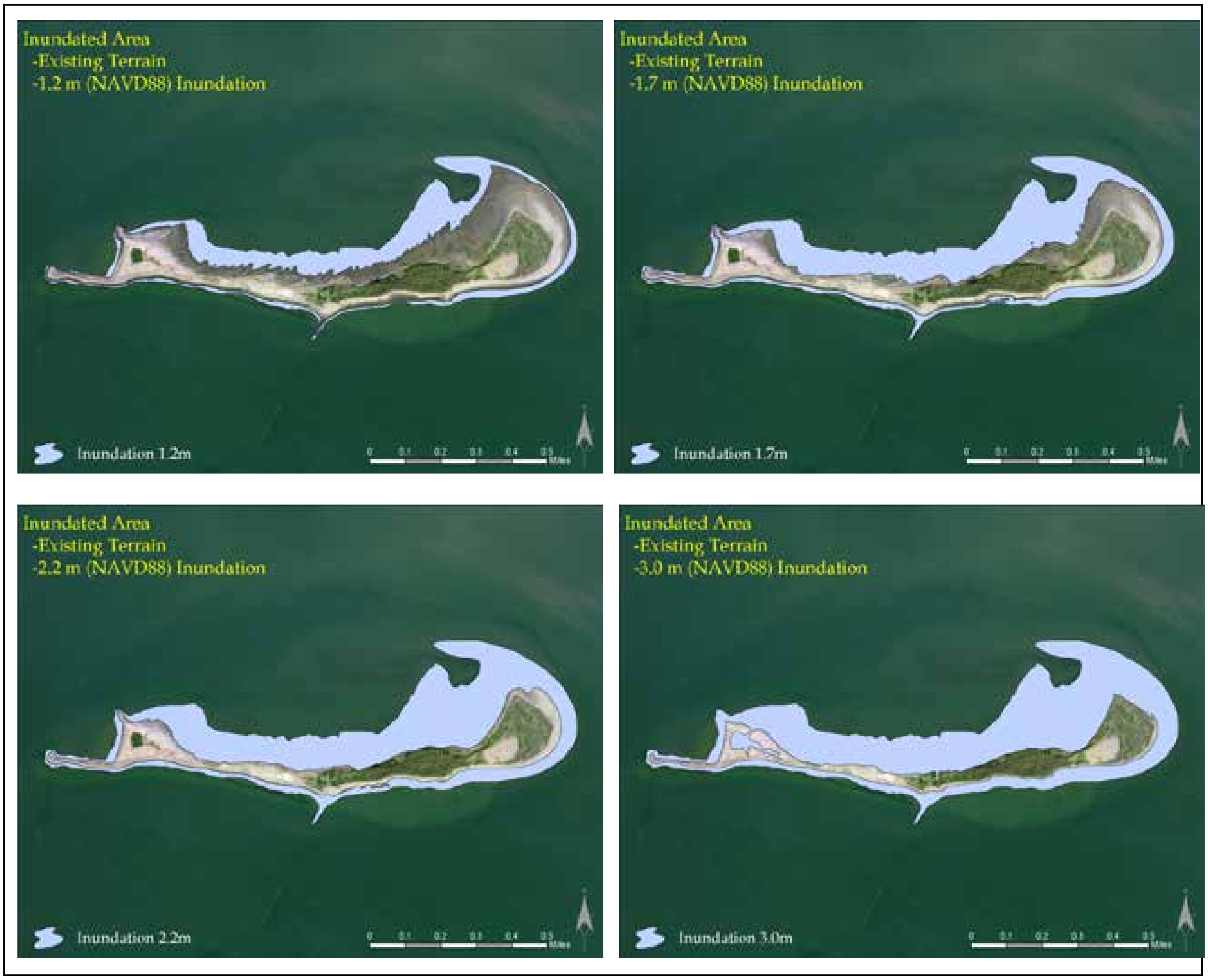


FIGURE 3-4. Water inundation outputs from the ATIIM for the existing terrain condition, representing four water surface elevations: 1.2, 1.7, 2.2, and 3.0 m (NAVD88).

Wetlands and Tidal Waters on East Sand Island

Wetlands and tidal waters were delineated on East Sand Island in February 2014 (Figure 3-5). A total of 7.135 acres (310,818 ft^2) of wetlands were delineated, including 6.026 acres (262,492 ft^2) of non-tidal freshwater wetlands and 1.109 acres (48,326 ft^2) of tidal wetlands (Green Banks 2014). Forty-three data collection plots were established throughout the island to document the presence or absence of wetland vegetation, soils, and hydrology. The Cowardin (Cowardin et al. 1979) and Hydrogeomorphic classes (Adamus and Field 2001; Adamus 2006) of these wetlands were also determined. Functional analyses were conducted on representative non-tidal and tidal wetlands identified during the study, using the protocol of the Oregon Department of State Lands *2010 Manual for the Oregon Rapid Assessment Protocol (ORWAP), Version 2.0.2* (ODSL 2010). The wetlands have moderate to high scores for several of the ORWAP "Grouped Functions," indicating that they are relatively high functioning wetlands that provide valuable habitat support for certain species, as well as improve water quality and carbon sequestration (Green Banks 2014).

FIGURE 3-5. East Sand Island wetlands and tidal waters.

Freshwater Non-Tidal Wetlands

The non-tidal wetlands contained a mix of palustrine scrub-shrub (PSS) and palustrine emergent (PEM) Cowardin classes. These wetlands generally have both Slopes and Flats Hydrogeomorphic (HGM) class components. The dominant plant species in these wetlands included: bentgrass (*Agrostis* species), black twinberry (*Lonicera involucrata*), Hooker willow (*Salix hookeriana*), red elderberry (*Sambucus racemosa*), soft rush (*Juncus effusus*), and yellow-flag iris (*Iris pseudacorus*). Hydric soil textures consisted of sandy loam, silt loam, and silty clay loam. Wetland hydrology indicators, such as a high water table, soil saturation, and oxidized root-channels, were observed. The three highest scoring ORWAP Grouped Functions in the non-tidal wetlands were: Water Quality, Aquatic Support Group, and Terrestrial Support Group.

Estuarine Tidal Wetlands

The tidal wetlands were located below the calculated highest measured tide elevation for the island

(11.34 feet [NAVD88]). The Cowardin class of these wetlands was estuarine emergent (EEM). Most of the tidal wetlands were "high marsh," with an HGM class of marine-sourced high tidal fringe. One tidal wetland contained both "low marsh" (marine-sourced low tidal fringe) and high marsh components. The dominant plant species in these wetlands included: Baltic rush (*Juncus balticus*), bentgrass, common velvetgrass (*Holcus lanatus*), Hooker willow, Pacific silverweed (*Argentina anserina*), slough sedge (*Carex obnupta*), and soft rush. Hydric soil textures consisted of sand and loamy sand. Indicators of wetland hydrology, such as a high water table, soil saturation, and inundation, were observed. The highest scoring ORWAP Grouped Functions in the tidal wetlands were: terrestrial support group, carbon sequestration, and aquatic support group.

Tidal Waters

The "waters" boundary of the Columbia River was delineated using two methods (gauge-calculated and field indicator) and a merged boundary line was created to achieve the highest level of accuracy in areas where either method had observed error. The highest measured tide (HMT) elevation was determined based on a river gage near Hammond, Oregon, that calculated the HMT to be 11.34 feet (NAVD88) during the 1983-2001 tidal epoch. Light Detection and Ranging (LiDAR) data for the island was used to locate this elevation in the field and to map the HMT in Geographic Information Systems (GIS). The HMT elevation was ground-truthed using Global Positioning System (GPS) and appeared to be fairly accurate based on the observation of field indicators at the same approximate elevation, with the exception of some areas where recent erosion has occurred or where the LiDAR data may have been less accurate (e.g. areas with dense vegetation or wood debris).

3.2.2 Double-crested Cormorants

Description and Life History

DCCOs are large, black to dark-brown, colonial-nesting, mainly fish-eating birds, often found in close proximity to marine or freshwater foraging sites. Average adult life expectancy is 6.1 years, and the oldest recorded banded DCCO was 17 years and 9 months (Van der Veen 1973; Hatch and Weseloh 1999). Mean age at first breeding is 2.74 years, with the majority of females breeding within their third year (van der Veen 1973). Mean clutch size is approximately 2.7 to 4.1 eggs; fledging success is approximately 1.2 to 2.4 young per nest (Hatch and Weseloh 1999). DCCOs commonly re-nest if clutches fail early in the year, but typically only raise one brood per breeding season.

Taxonomy, Distribution, and Management

DCCOs are native to North America, and their range extends across much of the continent. There are five recognized DCCO subspecies in North America (Figure 3-6) (Wires et al. 2001; USFWS 2003). Recent genetic analyses, however, supported the Alaska subspecies designation and presence of a divergent lineage associated with the southwestern portion of the species range (i.e., southern California and Baja California, Mexico), but found little support for recognition of subspecies within the conterminous U.S. and Canada (Mercer 2008, Mercer et al. 2013). The western population of DCCOs includes all breeding colonies within British Columbia, Washington, Oregon, Idaho, California, Nevada, Utah, Arizona, and the portions of Montana, Wyoming, Colorado, and New Mexico that lie west of the Continental Divide (Adkins et al. in press). The western population of DCCOs is a management population within the Pacific Flyway (Pacific Flyway Council 2012). The geographic scope of analysis lies within the boundary of the western population of DCCOs. Separate management of the western population of DCCOs from the Alaskan subspecies and populations east of the Continental Divide has been supported because of geographic and demographic separation and differences in population status (Carter et al. 1995; Tyson et al. 1997; Wires et al. 2001; USFWS 2003; Mercer 2013; Adkins et al. in press).

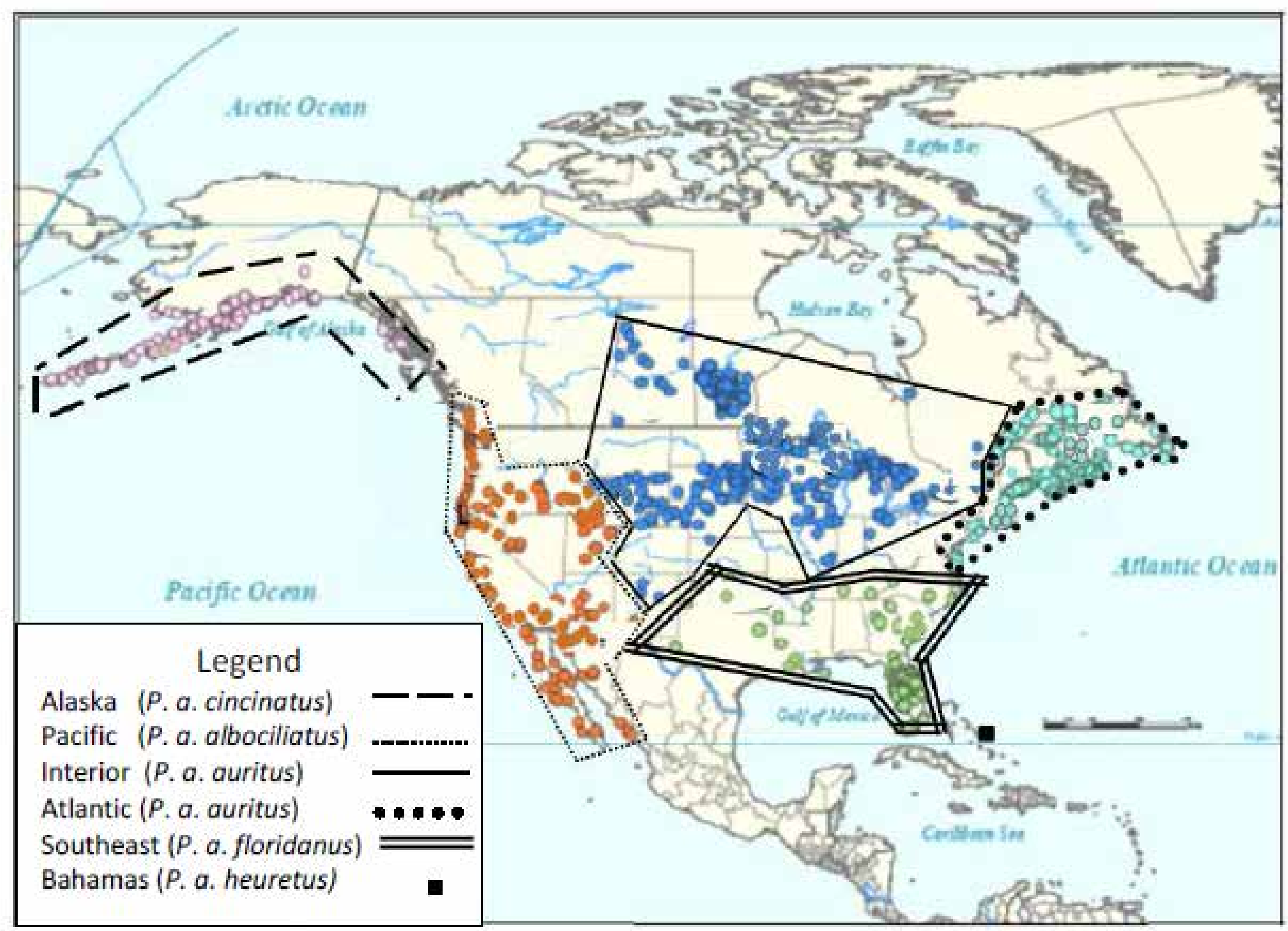


FIGURE 3-6. Breeding range of the five DCCO subspecies in North America (appended from Mercer 2008).

Habitat Requirements

DCCOs are habitat generalists and breed at lakes, marshes, rivers, bays, estuaries, coastlines, on rocky or sandy islands, offshore rocks, emergent vegetation, cliffs, trees, and human-made structures such as bridges, navigational aids, transmission towers, pilings, and jetties. DCCOs typically use breeding locations with protection from ground predators and within close proximity of foraging areas (typically less than 10 km; Hatch and Weseloh 1999). Ground-nesting may be the ancestral and preferred nesting habitat for DCCOs, whereas nesting in trees and other elevated structures could be a response to ground predators, human disturbance, and loss of natural breeding habitats (Lewis 1929; Carter et al. 1995; Hatch and Weseloh 1999).

DCCOs require similar habitat for foraging, loafing, and roosting during the non-breeding season as they do during the breeding season. Roosting and loafing sites are typically close to foraging areas and include exposed rocks, sandbars, shoals, coastal cliffs, offshore rocks, channel markers, pilings, wrecks, high-tension wires, utility poles, fishing piers, and trees. Non-breeders may roost at breeding colony sites or elsewhere during the night (Hatch and Weseloh 1999).

Diet

DCCOs are fish-eating, pursuit-diving birds that consume, on average, one pound of fish per day, usually comprised of small (<15 cm) fish (Hatch and Weseloh 1999; USFWS 2003). DCCOs are generalist feeders, preying on more than 250 species of freshwater and marine fish (Hatch and Weseloh 1999), but primarily on schooling forage fish (Lyons 2010). The composition of prey in the diet of DCCOs can vary considerably by location and throughout the year and is dependent on a number of factors, including the size, distribution, abundance, and behavior of fish (Collis et al. 2002; Lyons 2010; Hostetter et al. 2012). While their diet is almost entirely fish, DCCOs also feed on crustaceans, insects, and amphibians, although to a much lesser extent (Palmer 1962).

On East Sand Island, northern anchovy is the most prevalent DCCO prey type, followed by various marine and freshwater fishes, including clupeids, sculpins, and surf perch (Figure 3-7). Northern anchovy averaged approximately 30 percent of DCCO diet by biomass during 2001–2013 (Roby et al. 2014). On average, juvenile salmonids composed approximately 11.8 percent of DCCO diet by biomass during 1999–2013 (range 2 to 25 percent; Roby et al. 2014). Juvenile salmonid composition of DCCO diet by biomass was relatively stable at approximately 10 percent during 2006–2009, but was nearly double during 2010–2012. In 2013, diet composition was 10.7 percent juvenile salmonids. Osmerids (smelt) constituted 2 percent or less of DCCO diet on average during 2003–2010, but was atypically high in 2002 (8.7 percent). During 2002–2010, lamprey constituted 0.03 to 1.2 percent of DCCO diet each year (Roby et al. 2013).

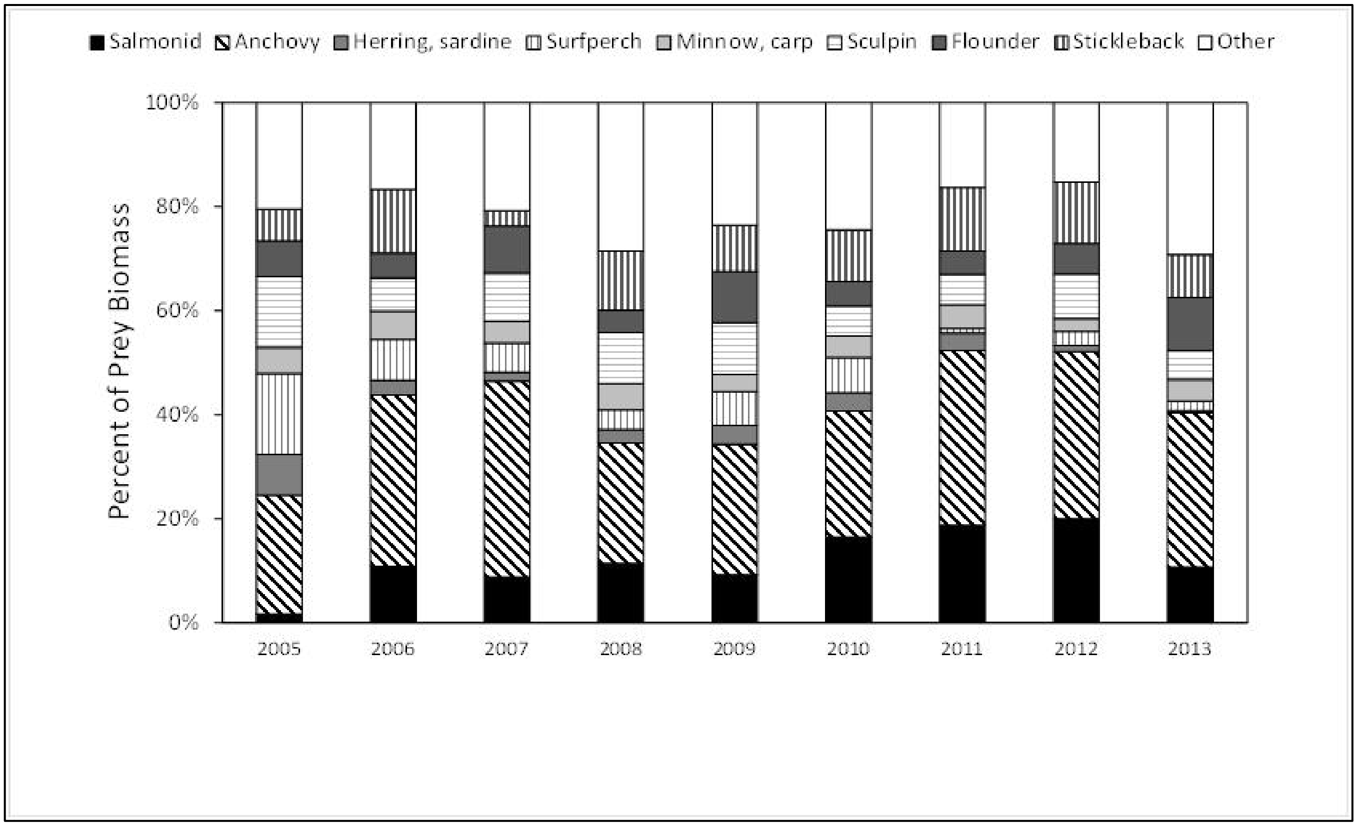


FIGURE 3-7. Annual diet composition (percent of prey biomass) of DCCOs nesting on East Sand Island during 2005–2013.

Colony Size

DCCOs are typically communal nesters, but the number of breeding pairs can vary widely (1 to >10,000) among locations and years (Wires et al. 2001; USFWS 2003; Adkins and Roby 2010). Colony sizes can change in response to environmental (e.g., drought, flooding), biological (e.g., increased predation, availability of prey), intra- or inter-colony dynamics (e.g., density dependence, proximity to other colonies), or anthropogenic factors (e.g., disturbance, management actions).

The East Sand Island DCCO colony, which has averaged approximately 12,917 breeding pairs during the past decade (2004-2013), is an unusually large, stable colony, compared to others in the western population of DCCOs. The majority of breeding colonies within the western population of DCCOs average less than 250 breeding pairs, and colony size can fluctuate greatly among years (Adkins and Roby 2010; Pacific Flyway Council 2012). Stable, suitable nesting habitat, an abundance of forage fish nearby, and predator protection, provided by safety in numbers, have contributed to the unprecedented growth and size of the DCCO colony at East Sand Island (Adkins et al., in press). These characteristics are not representative of DCCO habitat elsewhere in the affected environment.

Migration and Connectivity

DCCOs within the western population are thought to be less migratory compared to DCCOs within the interior and eastern U.S. (Hatch 1995; Wires et al. 2001). In many parts within the range of the western population, DCCOs are reported as year-round residents (Hatch 1995). DCCOs breeding in interior states west of the Continental Divide with harsh climates likely migrate to the Pacific Coast for the winter, but migration routes have not been concretely documented (Hatch 1995; Mercer 2008).

On East Sand Island, DCCOs are almost exclusively migratory, leaving East Sand Island after the breeding season (Courtot et al. 2012; Roby et al. 2013). DCCOs satellite-tagged on East Sand Island had the greatest connectivity with three estuarine and inner coastal regions to the north (Willapa Bay, Grays Harbor, and the Salish Sea) and the Western Columbia Basin (Courtot et al. 2012; BRNW unpublished data). These areas are likely better protected from winter weather extremes, compared to East Sand Island. Although satellite-tagged DCCOs were located from British Columbia to northern Mexico, there was little connectivity to colonies east of the Cascade-Sierra Nevada Mountains or along the coasts of Oregon, southern California, or Mexico (Courtot et al. 2012).

Population Status and Trend

Continental — DCCO abundance in North America has increased dramatically since the 1960s and 1970s, largely due to the growth of the Interior and Atlantic populations. Increases have largely been attributed to better environmental regulations, primarily restricting use of chlorinated hydrocarbons (e.g., DDT), protection under the MBTA in 1972, and decreases in hunting, compared to the early twentieth century (Hatch and Weseloh 1999). DCCOs have a status of "least concern," the lowest designation under the International Union for Conservation of Nature (IUCN) ranking system (IUCN 2011). During 1989–1995, the total estimated DCCO continental population was 372,410 breeding pairs; 91 percent of all breeding DCCOs resided in the Atlantic and Interior regions, 4 percent in the Southeast, and 5 percent in the West Coast-Alaska region (Tyson et. al. 1997; USFWS 2003).

Western Population and Affected Environment — The western population of DCCOs is an order of magnitude smaller than the DCCO populations in the interior and eastern United States (Tyson et. al. 1997; USFWS 2003), and the Pacific Coast population is likely an order of magnitude smaller than it was historically (Wires and Cuthbert 2006). The estimated size of the western population of DCCOs is approximately 31,200 breeding pairs (Adkins et al. in press; see Appendix F for a list of historic and current breeding colonies). From 1987–1992 to ca. 2009, the number of DCCO breeding pairs estimated within British Columbia, Washington, Oregon, and California increased by approximately 72 percent (i.e., 3 percent per year), or 12,000 breeding pairs, and large-scale distributional changes occurred (Adkins et al., in press; Pacific Flyway Council 2012). The coastal states and provinces account for greater than 90 percent of the western population (Adkins et al., in press). Based on Breeding Bird Survey data, DCCOs within the Western Breeding Bird Survey region (which closely aligns with the delineation of the western population of DCCOs) increased 2.9 percent per year (95 percent CI = -0.8 to 5.8 percent) during 1966–2009 and 7.5 percent per year (95 percent CI = -3.2 to 16.3 percent) during 1999–2009 (Sauer et al. 2011). Growth of the western population of DCCOs is largely attributed to the increase in size of the DCCO breeding colony at East Sand Island, which accounted for 39 percent of the western population of DCCOs during 2008–2010 (Figure 3-8; Adkins et al., in press).

The DCCO increase at East Sand Island likely initially resulted from immigration from other breeding colonies, as colony declines were documented over much of southern Alaska, British Columbia, Washington, and southern California during the same time period East Sand Island experienced growth (Carter et al. 1995; Hatch and Weseloh 1999; Moul and Gebauer 2002; Wires et al. 2001; Anderson et al. 2004b; Wires and Cuthbert 2006; Pacific Flyway Council 2012). Outside of East Sand Island, growth of the western population of DCCOs in other areas has been relatively static over the past two decades (see Figure 4-2), with some isolated areas of limited DCCO increase (e.g., Idaho, Montana, Arizona) and areas of decline or concern for continued decline (e.g., Salton Sea, California; Adkins et al., in press, Pacific Flyway Council 2012).

Within the range of the western population of DCCOs, there are approximately 197 active breeding colonies, of which 124 (63 percent) are located within the affected environment (Pacific Flyway Council 2013). The majority of the western population of DCCOs breeds along the coast (67 percent coastal vs. 33 percent inland; Figures 3-8 and 3-9; Adkins and Roby 2010). Colony information for the western population of DCCOs and affected environment was taken primarily from two sources: 1) the Pacific Flyway Council monitoring strategy for the western population of DCCOs (Pacific Flyway Council 2013) and 2) the status assessment of the western population of DCCOs (Adkins and Roby 2010). Pacific Flyway Council (2013) defined "active" as a breeding colony that contained five or more breeding pairs at least one time during 2008–2012. Adkins and Roby (2010) defined "active" as a breeding colony that contained one or more breeding pair at least one time during 1998–2009; thus the two datasets are not exactly comparable. In total, within the affected environment, 94 colonies were identified as active in both Pacific Flyway Council (2013) and Adkins and Roby (2010); in addition, there were 30 active colonies exclusive to Pacific Flyway Council (2013) and 67 active colonies exclusive to Adkins and Roby (2010). Thus, Pacific Flyway Council (2013) and Adkins and Roby (2010) identified 124 and 161 active colonies, respectively, and there were 191 active colonies in total from both sources combined (see Appendix F for list and map of colonies).

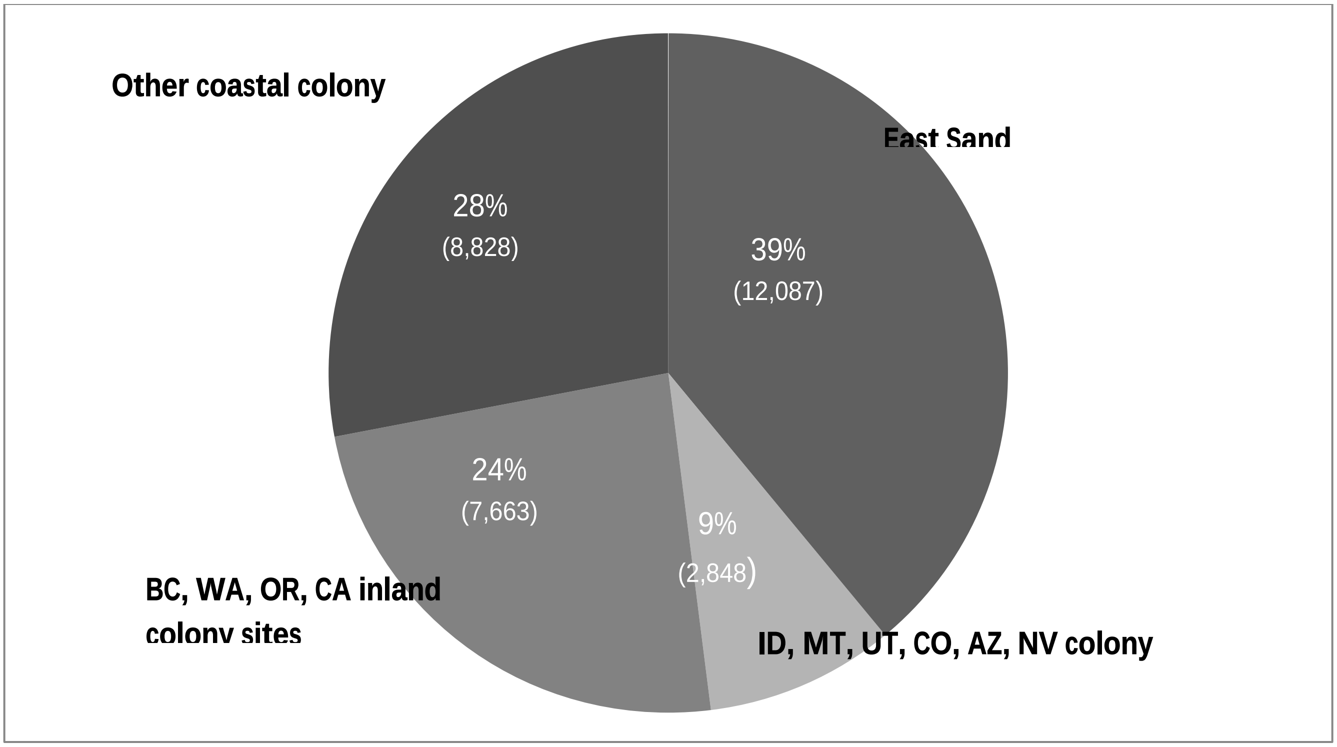


FIGURE 3-8. Percentage of DCCOs nesting at East Sand Island and other coastal and interior sites in the western population, using estimates through 2010 (from Adkins and Roby 2010).

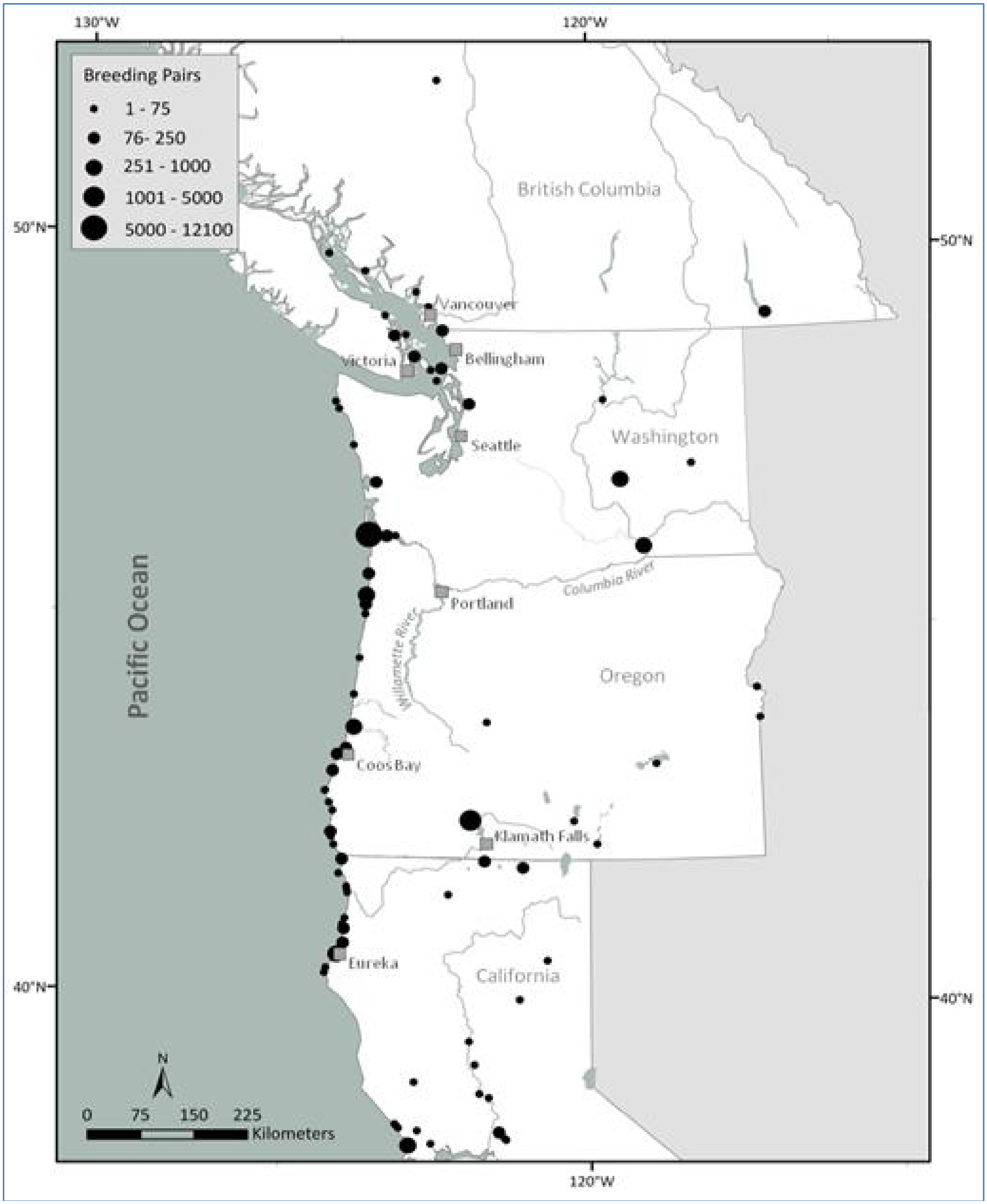


FIGURE 3-9. Distribution and relative size of DCCO breeding colonies in the Affected Environment during 1998-2009 (appended from Adkins and Roby 2010).

East Sand Island — DCCO nesting on East Sand Island was first documented in 1989, when less than 100 breeding pairs were reported (Naughton et al. 2007). By 1991, the estimated number of breeding pairs increased to 2,026 (Carter et al. 1995); this colony continued to grow and reached a peak estimate of 14,900 breeding pairs in 2013 (Roby et al. 2014). During the last decade (2004-2013) the average breeding colony size has been 12,917 breeding pairs (see Figure 1-2). DCCOs typically arrive on East Sand Island the last week of March, begin egg laying during the last week of April, and chicks hatch the last week of May (Figure 3-10). During 1997–2013, the average number of young raised per breeding pair was 1.83 (range = 1.2–2.8; Figure 3-11). The observed range on East Sand Island is slightly higher than the reported range for DCCOs (1.2–2.4 young raised per breeding pair; Hatch and Weseloh 1995).

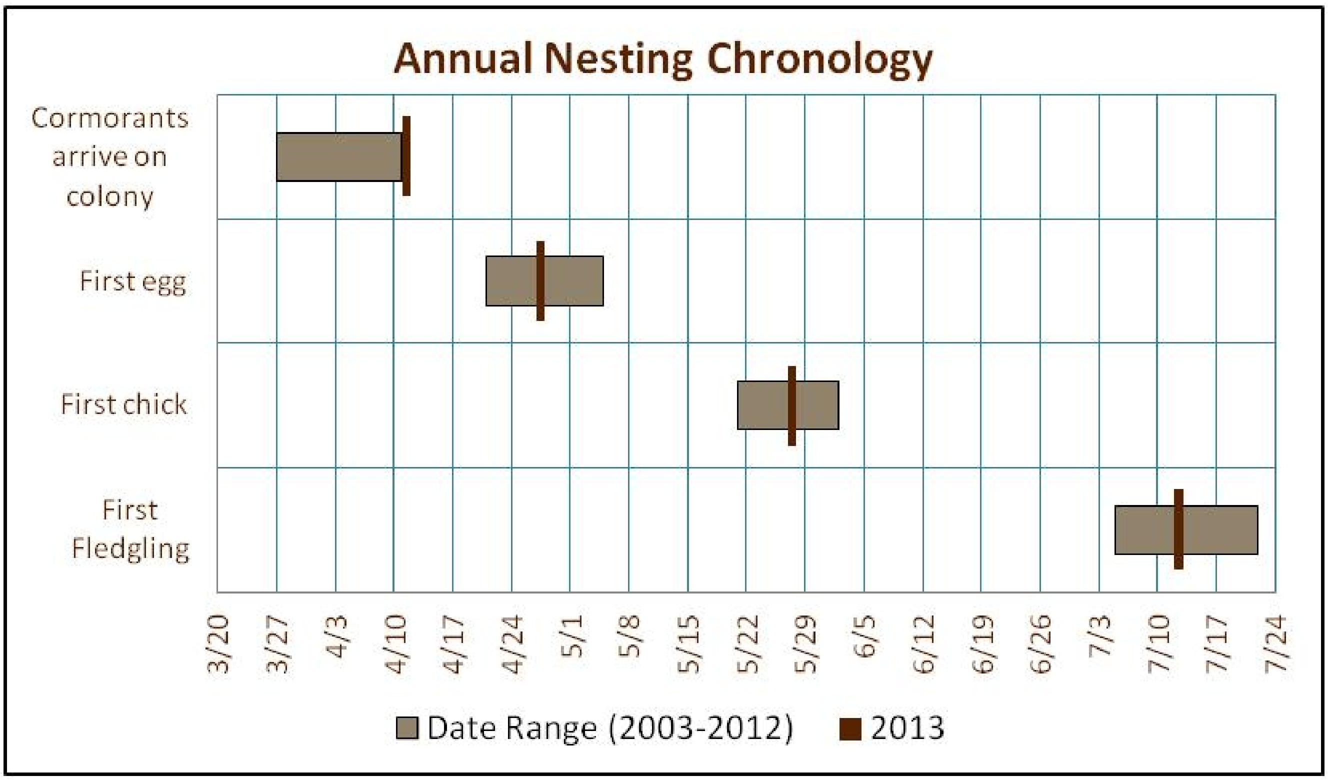


FIGURE 3-10. Nesting chronology of DCCOs on East Sand Island during 2003-2013.

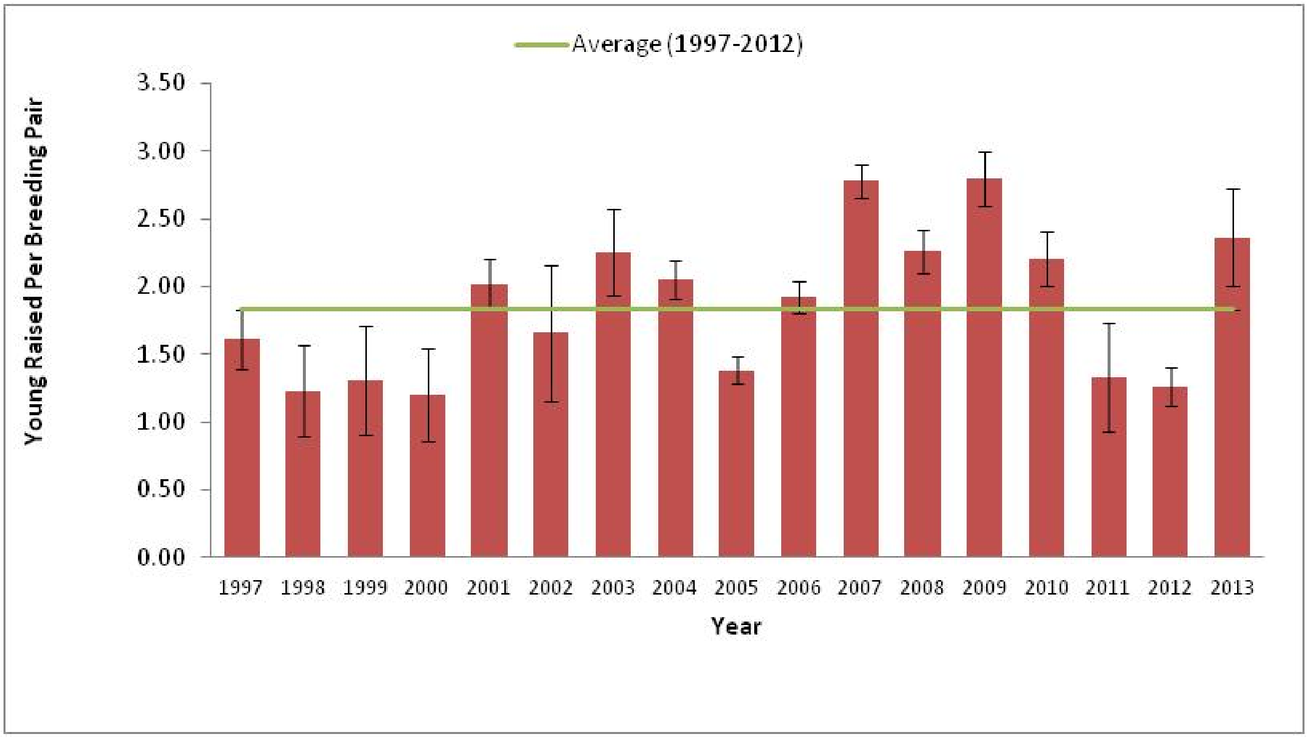


FIGURE 3-11. Young raised per breeding pair on East Sand Island during 1997–2013.

Columbia River Estuary — Within the Columbia River Estuary, DCCOs have nested at East Sand Island, Rice Island, Miller Sands Spit, Trestle Bay, Desdemona Sands pilings, Astoria-Megler Bridge, and on navigational aids around Miller Sands Spit and other nearby islands. Without the use of social attraction techniques, DCCOs last nested on Rice Island in 2003 and on Miller Sands Spit in 2001 (BRNW data, see Roby et al. annual reports). DCCO nesting was last observed at Trestle Bay or on the Desdemona Sands pilings in 1992 and 2000, respectively (Adkins and Roby 2010). DCCOs have nested on the navigational aids around Miller Sands Spit and other nearby islands annually since 1997 and on portions of the Astoria-Megler Bridge since 2004 (BRNW data, see Roby et al. annual reports). In 2013, a maximum of 330 and 231 DCCO breeding pairs nested on 11 navigational aids and the Astoria-Megler Bridge, respectively (Roby et al. 2014). Thousands of DCCOs were observed roosting on the Astoria-Megler Bridge at various times while dissuasion research was conducted (Roby et al. 2013, 2014).

Coastal Washington — It is difficult to establish a clear trend in the number of DCCOs breeding along coastal Washington (San Juan Islands, Eastern Strait of Juan de Fuca, Puget Sound, Olympic Peninsula Outer Coast, and Grays Harbor) during the last few decades. During 2009–2012, there were approximately 13 active breeding colonies in coastal Washington, which supported approximately 1,108 breeding pairs (Pacific Flyway Council 2013). In 2009, there were an estimated 788 breeding pairs (Adkins et al., in press), which was a 50 percent decrease from an estimated 1,564 breeding pairs in 1991–1992 (Carter et al. 1995, Adkins et al., in press). The majority (approximately 75 to 80 percent) of DCCOs within coastal Washington breed in the San Juan Island and Eastern Strait of Juan de Fuca areas (Adkins et al., in press; Pacific Flyway Council 2013). During 2009 aerial surveys, numerous bald eagles were observed in the vicinity of the seabird colonies along the coast, as well as two incidents of bald eagles actively disturbing colonies (Adkins and Roby 2010). Bald eagle disturbance and changes in prey availability may be limiting numbers of DCCOs nesting in coastal Washington.

In the San Juan Islands, an estimated 697 DCCO breeding pairs nested at 8 active breeding colonies during 2009–2012 (Pacific Flyway Council 2013). In 2009, 595 DCCO breeding pairs nested at 4 sites compared to 718 breeding pairs at 5 sites in 2003 (Adkins and Roby 2010). The potential for the Snohomish River mouth colony, the largest breeding colony in the San Juan Islands, to continue to support 250 or more breeding pairs is uncertain, as this colony is located among old creosote pilings, some of which were removed in 2008 and replaced with fewer steel pilings intended for osprey nesting habitat (Adkins and Roby 2010). Other relatively large colonies, Bird Rocks and Drayton Harbor, each support approximately 100 to 150 DCCO breeding pairs (Adkins and Roby 2010; Pacific Flyway Council 2013).

In the Eastern Strait of Juan de Fuca, 53 breeding pairs nested at 2 active breeding colonies during 2009–2012 (Pacific Flyway Council 2013). Twenty-eight DCCO breeding pairs nested at Smith Island in 2009 (Adkins and Roby 2010). A second nearby site, Protection Island, has not been active since 2008, when 11 breeding pairs were documented (Adkins and Roby 2010). These two islands supported approximately 100 to 150 breeding pairs during the late 1990s and early 2000s and an estimated 528 breeding pairs in 1992; however, complete nest failure in 1992 and the preceding two years was attributed to human and bald eagle disturbances (Carter et al. 1995; Adkins and Roby 2010). During 2009 aerial surveys, 15 or more and 5 bald eagles were observed in the vicinity of Smith Island and Protection Island, respectively (Adkins and Roby 2010). DCCOs at Smith Island, which had nested on the ground in the past, have restricted their nesting to one to two navigation towers on the island during the last few years (Adkins and Roby 2010). Another nearby site, Minor Island, was active as recently as 2012, when 25 breeding pairs were documented (Pacific Flyway Council 2013).

In the Puget Sound, one active breeding colony in Woodard Bay, with approximately 150 breeding pairs in 2012, was identified (Pacific Flyway Council 2013). There is some uncertainty, though, as to whether DCCO breeding actually occurs at this location. Numerous DCCOs are frequently observed loafing and roosting in this area, sometimes on nests, but it is also the location of a heron rookery. DCCO chicks or fledglings have not been confirmed (WDFW unpublished Data; D. Lyons personal communication). DCCOs have been observed foraging and loafing in other areas throughout the Puget Sound during the summer, but nesting has not been documented elsewhere (WDFW unpublished data).

In the Olympic Peninsula Outer Coast, there was one active breeding colony, Little Hogsback Island, with approximately 71 breeding pairs in 2009 (Adkins and Roby 2010). This is less than the approximate 100 to 200 breeding pairs at 5 to 10 active breeding colonies in the late 1990s (Adkins and Roby 2010).

In Grays Harbor, 143 DCCO breeding pairs nested on channel markers in 2013 (Roby et al. 2014). Since 2000, all DCCOs breeding in Grays Harbor have nested on channel markers, but there is no clear trend in the number of breeding pairs during this period. Numbers peaked in 2004, with 185 DCCO breeding pairs (Adkins and Roby 2010). In 2008, 52 DCCO breeding pairs were estimated, the lowest number since 2000 (Adkins and Roby 2010). In the early 1990s, a greater number of DCCOs nested in Grays Harbor, compared to the present: 191 breeding pairs at Goose Island and 249 breeding pairs at Unnamed Sand Island in 1992 (Carter et al. 1995). Goose Island has since washed away, and Unnamed Sand Island has not supported DCCOs nesting since 1999, when five breeding pairs were recorded (Adkins and Roby 2010).

Coastal Oregon — During 2009–2012, there were approximately 23 active breeding colonies in coastal Oregon (not including the Columbia River Estuary), which supported approximately 2,463 breeding pairs (Pacific Flyway Council 2013). In 2009, an estimated 2,384 DCCO breeding pairs nested at 22 sites along the Oregon coast (Adkins and Roby 2010). This is a modest increase from the 2003 and 2006 estimates of 2,216 and 1,903 breeding pairs at 24 and 21 sites, respectively (Naughton et al. 2007; Adkins and Roby 2010). Breeding pair numbers during 2003–2009 were 19 to 35 percent lower than the 1988–1992 estimate of 2,939 breeding pairs at 19 sites (Carter et al. 1995; Naughton et al. 2007). During this time period, DCCO nesting shifted from the Central Coast to the Southern Coast; 20 percent of all DCCO breeding pairs on the Oregon coast nested at Central Coast sites during 1988–1992, compared to 1 to 2 percent during 2003–2009 (Adkins and Roby 2010). Complementary DCCO increases occurred at colonies in the southern coast during these same time periods. Three Arch Rocks on the northern coast and Bolon Island on the southern coast are two of the largest coastal Oregon colonies in some years, with 439 and 763 breeding pairs, respectively, in 2009 (Adkins and Roby 2010). However, only 13 DCCO nests were observed on Bolon Island in 2013 (USFWS 2014b).

Coastal Northern California — During 2008–2011, there were an estimated 3,415 breeding pairs at 35 active breeding colonies (Pacific Flyway Council 2013). Of all the coastal California areas considered in Adkins and Roby (2010), the Coastal Northern California sub-area had the greatest decline in estimated abundance between 2003 and 2008. During 2008, there were an estimated 1,625 breeding pairs at 18 sites in Coastal Northern California compared to 2,437 breeding pairs at 19 sites during 2003, an approximate decrease of 33 percent or more (Adkins and Roby 2010). In 2008, this area supported approximately 33 percent of all DCCOs nesting on the California Coast, which was similar to the relative abundance in 2003 and 1989–1991 (Carter et al. 1995; Adkins and Roby 2010). Hog Island and Teal Island are two of the largest active breeding colonies in some years, supporting an estimated

548 (in 2011) and 485 (in 2008) breeding pairs, respectively (Adkins and Roby 2010; Pacific Flyway Council 2013). In 2003, 809 DCCO breeding pairs were documented at Arcata Bay Sand Island, but only 103 breeding pairs were observed in 2008 (Adkins and Roby 2010).

Coastal British Columbia — In British Columbia, DCCOs are a "blue-listed species" (i.e., species of special concern; B.C. Conservation Data Centre 2011). This designation results from low DCCO abundance in the province, as British Columbia is the northern extent of the range for the western population of DCCOs, and documented declines occurred at many breeding colonies during the 1980s and mid-1990s. In the Strait of Georgia (i.e., Vancouver Island and the lower coastal mainland), where the majority of DCCO colonies in British Columbia are located, there were an estimated 332 to 602 breeding pairs at 12 sites during 1999–2000, compared to 1,607–1,981 breeding pairs at 13 sites during 1983–1987, an approximate decrease of 66 percent or more (Moul and Gebauer 2002; Chatwin et al. 2002). Bald Eagle disturbance, subsequent depredation by gulls and crows, and human disturbance were thought to be the most serious factors limiting DCCO growth (Moul and Gabauer 2002). Response to oceanic and climatic conditions (Wilson 1991) and potential immigration to other areas (East Sand Island; Anderson et al. 2004b) also likely contributed to observed colony declines. Since the late 1990s, DCCO abundance has remained relatively stable at approximately 350 to 600 breeding pairs (Moul and Gabauer 2002; Adkins and Roby 2010). DCCO abundance in coastal British Columbia in the winter (i.e., non-breeding season) has increased during the past decade (Badzinski et al. 2008).

Interior Washington — There are approximately 7 active breeding colonies in interior Washington, and these sites supported approximately 1,544 breeding pairs in 2011 (Pacific Flyway Council 2013). Nearly all DCCOs in interior Washington breed on the Columbia River Plateau, with some small colonies near the Pend Orielle River and Spokane. Roby et al. (2014) documented 1,406 DCCO breeding pairs at four sites (Foundation Island, North Potholes Reservoir, Sprague Lake, Okanogan River) on the Columbia River Plateau in 2013, which was slightly higher than the average of approximately 1,356 breeding pairs during 2005–2012. Long-term trends in interior Washington during the past decades are unclear, as comprehensive, systematic surveys of areas were not conducted until early to mid-2000s. Since 2005, DCCO abundance in the Columbia River Plateau has been relatively static, with a gradual increase in DCCO abundance during 2009–2012 and a slight decrease in 2013 (Figure 3-12). North Potholes Reservoir and Foundation Island are the largest active breeding colonies, averaging approximately 950 and 325 breeding pairs, respectively, during the past decade (Roby et al. 2014).

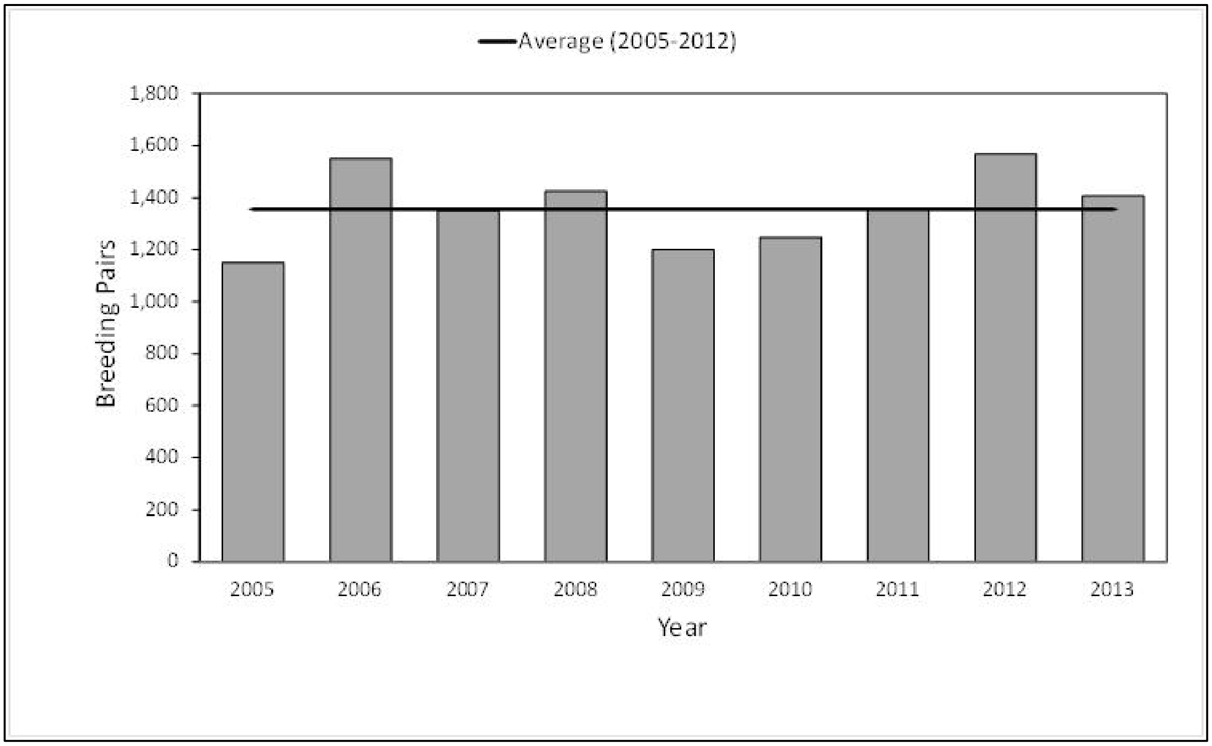


FIGURE 3-12. Estimated total number of DCCO breeding pairs in the Columbia Plateau region during 2005–2013.

Interior Oregon — During 2009–2011, there were approximately 18 active breeding colonies in interior Oregon (Pacific Flyway Council 2013). These sites supported approximately 1,040 and 800 DCCO breeding pairs in 2009 and 2011, respectively (Adkins and Roby 2010; Pacific Flyway Council 2013). Klamath Basin in southeastern Oregon has the greatest concentration of DCCOs in interior Oregon. DCCO abundance at specific sites often fluctuates greatly or exhibits cyclical increases and decreases depending on environmental and water conditions and levels of disturbance. Sites in close spatial proximity can function as a network of ephemeral sites; thus, there is likely less fluctuation in abundance at larger spatial scales. However, comprehensive, systematic survey efforts in interior Oregon have been lacking, and it is unclear if DCCO abundance in interior Oregon has changed in recent decades (Shuford 2010). Upper Klamath NWR and Malheur Lake and NWR are two of the largest active breeding colonies. Upper Klamath NWR supported 850 to 1,000 DCCO breeding pairs during 2003–2009 (Adkins and Roby 2010), but 250 breeding pairs were present in 2011 (Pacific Flyway Council 2011). Malheur Lake and NWR supported approximately 250 breeding pairs in the late 1990s and in 2011, but few to no breeding pairs were documented in the late 2000s (Adkins and Roby 2010; Pacific Flyway Council 2013).

Interior Northern California — During 2009–2011, there were approximately 16 active breeding colonies in interior Northern California, and these sites supported approximately 586 breeding pairs (Pacific Flyway Council 2013). The Klamath Basin in northeastern California has the greatest concentration of DCCOs in interior California. Smaller active breeding colonies also occur along the

Sacramento River. As described above for interior Oregon, DCCO abundance at specific sites often fluctuates and comprehensive, systematic survey efforts have been lacking; thus, it is unclear if DCCO abundance in interior California has changed in recent decades (Shuford 2010). In 2009, an estimated 259 breeding pairs nested at five colonies in the Klamath Basin, which was much lower than the estimated 521 to 604 breeding pairs from partial surveys during 1992–2004 (Adkins and Roby 2010). Lower Klamath NWR and Clear Lake NWR are two of the largest active breeding colonies, and abundance at these sites has fluctuated greatly. The number of DCCO breeding pairs at Sheepy Lake in Lower Klamath NWR dropped from 978 in 1997 to 62 in 1999 because of water levels changes (Shuford 2010). In 2011, Sheepy Lake had an estimated 55 breeding pairs (Pacific Flyway Council 2013). At Clear Lake NWR, there were an estimated 97 to 200 breeding pairs during 1995–1999 and abundance peaked at 375 breeding pairs in 2000 (Shuford 2010). In 2011, Clear Lake had an estimated 148 breeding pairs. Tule Lake NWR supported approximately 150 breeding pairs in the late 1990s, but this site has not been active recently (Adkins and Roby 2010; Pacific Flyway Council 2013).

Interior British Columbia — There is one small DCCO breeding colony at the Creston Valley Wildlife Management Area (WMA). DCCO breeding pairs increased from relatively few to 98 or fewer breeding pairs during 1999–2008 (Adkins and Roby 2010).

3.2.3 Other Birds Common to East Sand Island

Other birds that could be affected by the proposed alternatives are other colonial waterbirds co-nesting or roosting on East Sand Island or other birds commonly found on the island during the nesting season when management actions are underway. Gulls, Caspian terns, Brandt's cormorants, and California brown pelicans are present in large numbers on the island (Table 3-2). Several raptors (e.g., eagles, owls, falcons) are also present on the island foraging on adults, eggs, and chicks. In 2012, up to 20 bald eagles were observed on the DCCO colony, killing adults and consuming eggs (BRNW unpublished data). Bald eagles also flush Caspian terns nesting in the designated tern colony, and subsequent gull predation of tern eggs has caused declines in tern productivity over the past several years.

Waterfowl nest on and use East Sand Island, although in far fewer numbers than nesting waterbirds. Areas most commonly used by waterfowl are the grassy areas on the eastern and central portions of the island. East Sand Island is within the Columbia River Estuary, which, from the mouth to RM 60, is designated as a site of regional importance to shorebirds by the Western Hemispheric Shorebird Reserve Network. Shorebirds frequent East Sand Island to roost and forage and are observed in the tidal flats and beaches. Additionally, a variety of songbirds are present in the more vegetated areas on the central portion of the island. Most, if not all of these birds, overlap with DCCOs throughout the affected environment.

A substantial amount of nesting and roosting habitat is available to birds on East Sand Island. There are approximately 60 acres of upland habitat (area above high tide) on East Sand Island, composed of vegetated (low lying grasses, shrubs, and trees), bare sand substrate, and riprap rock embankment (Figure 3-13). The amount of intertidal habitat, defined as the island area below the maximum high tide line, varies by tidal phase, with more area available to waterbirds and shorebirds during ebb and low tides. During low tide stages on East Sand Island, up to 90 acres of intertidal habitat can be available. This habitat is primarily used by roosting waterbirds, yet occasionally waterbirds nest in the upper intertidal zone, although nests are often inundated and destroyed during extreme high tide or storm events.

FIGURE 3-13. East Sand Island land cover classes.

A complete list of birds observed on East Sand Island during the 2013 nesting season is provided in Appendix G. All birds referenced in this document are protected under the Migratory Bird Treaty Act and some have additional protections, which are noted. The primary co-nesting or roosting waterbird species on East Sand Island other than DCCOs are described below in more detail (Table 3-2; see Chapter 4, section 4.2.2 for additional information concerning temporal and spatial usage of the island). Population estimates were taken primarily from the Pacific Region Seabird Conservation Plan (USFWS 2005b).

TABLE 3-2. Primary Co-nesting or Roosting Waterbirds on East Sand Island Other than DCCOs.

Species	Federal, State, Provincial, and Other Conservation Status*	Relationship to DCCO on East Sand Island	Estimated #'s on East Sand Island	Estimated Regional Breeding Population (individuals)
Brandt's Cormorants	RL (BC); SC (WA); HC	Co-nesting within DCCO colony on western portion	<1,600 nesting pairs	~74,000 (WA, OR, CA)
California Brown Pelicans	E (WA); E (OR); MC	Roosts on East Sand Island; use inter-tidal zone and adjacent upland habitat	>10,000 roosting individuals	~100,000 (Western Region)
Caspian Terns	BL (BC); BCC; LC	Nest primarily on eastern portion but terns have attempted to nest near DCCO on western portion	~7,000 nesting pairs	~22,000 (Pacific Region)
Glaucous Winged/Western Gull	LC/NCR	Predator of DCCO eggs and chicks; nests throughout the island and adults present throughout the island	~4,000 individuals	~73,000 (WA, OR)
Ring-Billed Gulls	NCR	Beach area near Caspian tern colony	~1,400 nesting pairs	~17,000 (Pacific Coast)

*Federal ESA Status (FED): NL= not listed, CS= candidate species, T= threatened, E= endangered; British Columbia status: BL=blue listed; RL= red listed; State-listed: C= sensitive-critical, SC= state candidate, SSC= species of special concern, V= sensitive-vulnerable; BCC= 2008 Birds of Conservation Concern; North American Waterbird Conservation Plan (2002): NCR= not currently at risk, LC= least concern, MC= moderate concern, HC= highest concern.

Bald Eagles *(Haliaeetus leucocephalus)*

Bald eagles are protected under the Bald and Golden Eagle Protection Act and are common along the Washington and Oregon coast and freshwater rivers and streams at low elevations (Watson et al. 2002; Marshall et al. 2006). Bald eagles that breed along the lower Columbia River are primarily year-round residents and do not migrate. During the 1980s and early 1990s, bald eagles in this area experienced low reproductive success, characteristic of a declining population. High contaminant concentrations were thought to account for this population's low productivity (Anthony et al. 1994). The resident population has recently increased, likely as a result of recruitment of new adults from other areas (Watson et al. 2002). In addition to the resident population, migrant bald eagles from other regions overwinter on the lower Columbia River.

Breeding bald eagles are less common in eastern Washington, Oregon, and Idaho, although scattered pairs nest along lakes, reservoirs, and rivers (Stinson et al. 2007; Pacific Biodiversity Institute 2008). In winter, migrant bald eagles move into the region, focusing on salmon spawning streams and waterfowl wintering areas. In eastern Washington and Idaho, the reservoirs and major tributaries of the Columbia River and Snake River are important wintering habitats (Stinson et al. 2007). A nesting survey found 401 breeding pairs in Oregon and 40 on the Washington side of the Columbia River in

2002. Bald eagles were delisted from the ESA in 2007 and have exceeded recovery expectations. Recent increases in their numbers along the Pacific coast have been associated with substantial disturbance to nesting seabirds and waterbirds.

Brandt's Cormorants *(Phalacrocorax penicillatus)*

Brandt's cormorants nest on East Sand Island within the DCCO colony (Roby et al. 2014). Brandt's cormorant temporal use of the island generally coincides with DCCOs (April–October), but their arrival and nesting stages are a few weeks later compared to DCCOs. An established breeding colony of Brandt's cormorants on East Sand Island was first documented in 2006, with 44 breeding pairs (BRNW data). Abundance steadily grew until 2012, when 1,684 breeding pairs were estimated; in 2013, 1,523 breeding pairs were estimated (Roby et al. 2014). The Brandt's cormorant regional population (WA, OR, and CA) is approximately 74,000 breeding individuals (Table 3-2).

California Brown Pelicans *(Pelecanus occidentalis)*

East Sand Island is the largest known post-breeding nighttime roost site for California brown pelicans in the region, supporting more than 10,000 individuals in some years, and the only known night roost for this species in the Columbia River Estuary (Wright 2005). California brown pelicans typically begin arriving to East Sand Island in very low numbers in April, and peak usage is in August. They use the intertidal zone and adjacent upland habitat, and tend to avoid roosting on broad mud flats or densely vegetated interior portions of East Sand Island.

In 2013, the first California brown pelicans were observed roosting on East Sand Island in late April, and their numbers peaked in late August at about 3,850 roosting individuals, significantly less than the peak counts in 2011 (approximately 14,225 individuals; Roby et al. 2014; see Chapter 4, section 4.2.2 for monthly counts during 2006–2013). California brown pelican breeding behavior has been observed on East Sand Island (i.e., courtship displays, nest-building, etc.), and, in July 2013, three nests were documented on a grassy slope southeast of the Caspian tern colony, all of which contained eggs (one nest with 3 eggs and the other two nests with one egg each). These nesting attempts failed due to natural predation, and all three nests were abandoned by late July (Roby et al. 2014). This is the first documented egg laying by California brown pelicans on East Sand Island or in Oregon; the nearest known colony is on the Channel Islands in Southern California.

California brown pelicans occur along the Pacific Northwest coast from June to October where they feed opportunistically in shallow marine waters, including bays and estuaries, and near offshore islands, spits, breakwaters, and open sand beaches (Seattle Audubon Society 2005). In Washington, their numbers are highest at communal roosts and on the coastline at Gray's Harbor, Ocean Shores, and Copalis, Washington (Opperman 2003; Seattle Audubon Society 2005). Their diet on the west coast consists primarily of schooling anchovies, eulachon, herring, Pacific mackerel, minnow, and sardines (Seattle Audubon Society 2005). Although available information does not indicate that

California brown pelicans prey on salmon and steelhead, it is possible that the opportunistic foraging behavior would result in consumption of some salmon and steelhead. In 2005, the California brown pelican breeding population in the western region was estimated to be approximately 100,000 breeding individuals (Table 3-2). In 2008, brown pelicans were removed from listing under the ESA. A draft California brown pelican monitoring plan was prepared by the USFWS.

Caspian Terns *(Hydroprogne caspia)*

The distribution of the regional population of Caspian terns in the Pacific Flyway dramatically changed during the 1980s and 1990s, likely as a result of immigration to the Lower Columbia River Estuary. Caspian tern breeding was first documented in the Columbia River Estuary in 1984 when approximately 1,000 terns were reported nesting on fresh dredged material disposed on East Sand Island. Prior to 1984, the species was a non-breeding summer resident of the lower Columbia River. In 1986, possibly because of vegetation development on East Sand Island, the colony moved to Rice Island where they nested until the Corps took actions to relocate the terns via social attraction to East Sand Island.

From the early 1980s estimate of approximately 6,000 breeding pairs (Gill and Mewaldt 1983), the Pacific Region Caspian tern population approximately doubled to 11,593 breeding pairs in 2011 (Collis et al. 2012). Abundance peaked in 2009 at approximately 19,000 breeding pairs and declined thereafter. This decline corresponded with a concurrent decrease in the East Sand Island colony (see below). The current estimate of the Pacific region population is approximately 11,000 breeding pairs (Table 3-2). The Caspian tern colony on East Sand Island is the largest in the world (Roby et al. 2014). Approximately 60 percent of the regional population currently resides on East Sand Island (M. McDowell, USFWS, personal communication). Caspian terns nest on the eastern end of the island, separated from the DCCO and Brandt's colonies by dense upland shrub habitat. The number of adult Caspian terns on the East Sand Island colony peaks in mid-May. A large number of terns use East Sand Island for nighttime roosting.

The number of breeding tern pairs on East Sand Island peaked in 2008 at 10,700 breeding pairs and declined incrementally through 2012 (i.e., 6,400 breeding pairs), as available habitat was gradually reduced. In 2013, abundance slightly increased to 7,400 breeding pairs, despite nesting acreage remaining constant from 2012 to 2013 (Roby et al. 2014). In 2013, approximately 0.20 young per breeding pair were produced, a significant increase, as production was zero or near zero during 2010–2012. In 2011, the colony did not produce any young; this is the first time that complete breeding failure was documented (Roby et al. 2012). Low productivity has been attributed to high levels of disturbance by bald eagles and associated gull predation on tern eggs and chicks.

Ring-billed Gulls (*Larus delawarensis*)

Ring-billed gulls nest in close association with the Caspian tern colony on the east end of the island, and their nesting chronology is similar to that of Caspian terns, with nesting ring-billed gulls present on the island from April through July. During 2013, an estimated 2,680 individuals nested on East Sand Island (Roby et al. 2014). During 2010–2012, estimated abundance was 1,417, 1,944, and 1,472 individuals, respectively (Roby et al. 2011, 2012, 2013).

Within the Columbia River Estuary, ring-billed gulls have been observed nesting on Miller Sands Spit (Collis et al. 2002), and several hundred individuals were counted on a colony on the western portion of Rice Island. The numbers of ring-billed gulls in the Lower Columbia River Estuary have increased since 1998; 2,550 ring-billed gulls were counted on colonies in the Columbia River Estuary during a comprehensive survey in the 2009 nesting season compared to less than 100 in 1998 (Collis et al. 2002). The continental ring-billed gull population has increased throughout the last century, and, in 2005, the estimated continental population size was approximately 1,700,000 individuals, with less than 1 percent breeding along the Pacific Coast. The current estimate of the Pacific Coast regional population is approximately 17,000 breeding individuals (Table 3-2).

Glaucous-winged/Western Gulls *(Larus glaucescens/occidentalis)*

Of all the colonial waterbirds that nest on East Sand Island, Glaucous-winged/western gulls are the only species that nest on both the eastern and western portions of the island. Glaucous-winged/western gulls are the first to arrive on the island (before March) and initiate nest territory defense (early March). The peak nesting period is in May and June, with some individuals remaining on the island as late as November. Glaucous-winged/western gulls are increasing throughout the Pacific Coast of North America, with an estimated regional population (WA and OR) of approximately 73,000 breeding individuals (Table 3-2).

In 2013, an estimated 4,580 Glaucous-winged/western gulls nested on East Sand Island and Rice Island. Glaucous-winged/western gulls typically breed on Miller Sands Spit, but breeding was not documented in 2013 (Roby et al. 2014). The number of Glaucous-winged/western gulls at these three colonies at the peak of nesting was 6,966, 6,776, and 3,369 individuals during 2010, 2011, and 2012, respectively. In 2012, estimated abundance on Rice Island and Miller Sands Spit was approximately 1,000 and 200 to 500 individuals, respectively (Roby et al. 2011, 2012, 2013).

Waterfowl

Mallards (*Anas platyrhynchos*) and western Canada geese (*Branta canadensis moffitti)* are the most abundant breeding waterfowl on the islands in the Lower Columbia River Estuary (USFWS 2010). Non-breeding brant (*Branta bernicla*) are observed on East Sand Island during the summer. Nesting waterfowl mainly occur in vegetated areas on the east end of East Sand Island (BRNW 2013b).

3.2.4 Other Birds

For other birds within the affected environment outside of East Sand Island, consideration in the EIS is primarily limited to bird species that could potentially be impacted by the proposed alternatives. Focus is on species within the sub-regions of the affected environment, particularly the Columbia River Estuary, Washington Coast, and Salish Sea, and specifically to those species that co-nest or overlap in habitat use with DCCOs and are a conservation concern. DCCOs are colonial waterbirds and commonly nest with other waterbirds. All of the bird species co-nesting or roosting with DCCOs on East Sand Island also occur with DCCOs in other areas in the affected environment. These species were described in Chapter 3 section 3.2.3, and thus, are not included again in this chapter. Co-nesting species have the potential to be most impacted by large increases of DCCOs at a location through nest-site competition and possible displacement.

Bird species identified by the cooperating agencies for consideration in the EIS are given in Table 3-3 and described below in more detail. Birds listed under the ESA within the affected environment, the sub-regions, and the Columbia River Estuary are provided in Appendix H. Only one bird species of federal conservation concern, the streaked horned lark, which was recently designated as threatened, was identified on both lists. In the Columbia River Estuary, Rice Island (a dredged material site and former colony site for DCCOs and Caspian terns) and other identified potential DCCO dispersal and hazing locations were recently designated critical habitat for streaked horned larks. DCCO dispersal to and subsequent necessary hazing activities on islands in the estuary identified as critical habitat for streaked horned larks have the potential to adversely affect the larks. The Corps' Channels and Harbors Program has completed consultation with the USFWS for the continued operations and maintenance dredging program for the Columbia River Federal Navigation Channel. For this EIS, the Corps is currently preparing a biological assessment for the proposed management plan and will consult with USFWS under Section 7 of the ESA. Hazing activities on the Corps' dredge material islands would occur under the Corps' Channels and Harbors Program in consultation with the USFWS Endangered Species program.

American white pelicans and pelagic cormorants nest in the Columbia River Estuary. The other species identified in Table 3-3 primarily nest along coastal areas outside of the Columbia River Estuary. As stated in Chapter 3, section 3.1, outside of the Columbia River Estuary, the Washington Coast and the Salish Sea areas likely have the greatest potential for immigration of DCCOs deterred from nesting on East Sand Island and the Columbia River Estuary. Waterbird declines have been documented in the Salish Sea area over the past decades (Bower 2009; Crewe et al. 2012). Increased numbers of DCCOs immigrating to this area have the potential to affect the other bird species present.

TABLE 3-3. Other Birds Found with DCCO in the Affected Environment.

Species	Federal, State, Provincial, and Other Conservation Status*	Where Found with DCCOs	Estimated Regional Breeding Population (individuals)
American White Pelican	RL (BC); E (WA); V (OR); SSC (CA); MC	Columbia River Estuary, nests on Miller Sands Spit; breeding colonies in interior B.C., WA, and in the Klamath Basin of SE OR and NE CA.	~46,000 (Western Pop)
Pelagic Cormorant	RL (BC); BCC; HC	Columbia River Estuary, nests on Astoria-Megler Bridge and other in-water structures; coastal CA to B.C.	~29,000 (Pacific Region)
Streaked Horned Lark	T (ESA); E (WA); C (OR); BCC	Columbia River Estuary, Rice Island, Brown Island; south Puget Sound and Washington Coast.	~150 (OR and WA)
Black Oystercatcher	V (OR); BCC	Coastal CA to B.C., concentrations in Salish Sea; nests on non-forested islands with gravel or shell beaches.	~10,000 (N. America)
Cassin's Auklet	BL (BC); SC (WA); V (OR); SSC (CA); BCC; MC	Coastal CA to B.C, with <1 percent in OR.	~180,000 (Pacific Region)
Rhinoceros Auklet	V (OR); LC	Coastal CA to B.C., primarily WA, B.C, and Salish Sea.	~1,000,000 (N. America)
Common Murre	RL (BC); SC (WA); MC	Coastal CA to B.C.; *U. a californica* primarily in OR and CA.	~1,000,000 (WA, OR, CA; *U. a californica*)
Fork-tailed Storm-Petrel	SSC (CA)	Coastal N CA to B.C, primarily WA.	~5,000 (WA, OR, CA)
Leach's Storm-Petrel	LC	Coastal CA to B.C, primarily OR.	~450,000 (WA, OR, CA)
Pigeon Guillemot	MC	Coastal CA to B.C., primarily WA and CA.	~38,000 (WA, OR, CA)
Tufted Puffin	BL (BC); SC (WA); V (OR); SSC (CA); LC,	Coastal CA to B.C., primarily B.C. and WA and Three Arches NWR in OR.	~<15,000 (WA, OR, CA)
Pacific Great Blue Heron	BL (BC); NCR	Arboreal nester; coastal B.C. south to Puget Sound.	~10,000 (B.C. and WA)

*Federal ESA Status (ESA): NL= not listed, CS= candidate species, T= threatened, E= endangered; British Columbia status: BL=blue listed; RL= red listed; State-listed: C= sensitive-critical, SC= state candidate, SSC= species of special concern, V= sensitive-vulnerable; BCC= 2008 Birds of Conservation Concern; North American Waterbird Conservation Plan (2002): NCR= not currently at risk, LC= least concern, MC= moderate concern, HC= highest concern.

American White Pelican (*Pelecanus erythrorhynchos*)

The first nesting record of American white pelicans in the Columbia River Estuary occurred at Miller Sands Spit during 2010. Since that time, the colony has averaged approximately 100 individuals each year. In 2013, a minimum of 104 individuals was estimated (Roby et al. 2014). While estimates of nesting success are unavailable, American white pelicans were successful in raising young at the Miller Sands Spit colony during 2010-2012 (data were unavailable for 2013; Roby et al. 2014). American white pelicans in the Columbia River Estuary compose a small portion of the western population of American white pelicans, which is estimated to be approximately 46,000 breeding individuals (Pacific Flyway Council 2012a).

Pelagic Cormorant *(Phalacrocorax pelagicus)*

Similar to DCCOs, pelagic cormorants nest on coastal mainland cliffs and offshore islands and occupy bridges and other in-water structures. Colony sizes are typically less than 100 individuals. In 2013, an estimated 72 breeding pairs nested on the Astoria-Megler Bridge, slightly lower than the 106 breeding pairs estimated in 2012 (Roby et al. 2014). This is the only known pelagic cormorant nesting site within the Columbia River Estuary. Pelagic cormorants have been observed nesting on the southern portion of the bridge since surveying began in 1999 (Roby et al. 2013). The number of pelagic cormorants in the Columbia River Estuary composes a small portion of the Pacific Region population; approximately 29,000 pelagic cormorants breed in the Pacific Region, with the majority (more than 40 percent) of the population breeding in California. In the Salish Sea region, there has been increasing or no significant trend observed in pelagic cormorant wintering abundance, but declines of breeding abundance have been documented in this area (Bower 2009; Crewe et al. 2012).

Streaked Horned Lark (*Eremophila aipestris strigata*)

The streaked horned lark was listed as threatened under the ESA in 2013. Critical habitat has been designated on many islands within the Columbia River Estuary (50 CFR 17.95(b)). Fewer than 100 breeding adults are found in the Columbia River Estuary. A key attribute of habitat used by streaked horned larks is open landscape context. Streaked horned larks nest on the ground in sparsely vegetated sites dominated by grasses and forbs and are known to occupy dredged material islands typically after 1 to 3 years of a disposal event when vegetation emerges (Pearson and Altman 2005; Pearson et al. 2005). The majority of breeding individuals in the Columbia River Estuary are found on Rice and Brown Island. In 2013, 22 breeding pairs were observed on Rice Island. Current range-wide populations are estimated to be about 1,170 to 1,610 individuals, with 150 to 170 breeding individuals at six sites in Oregon and Washington.

On Rice Island, streaked horned larks have been observed nesting on the plateau region of the Corps' dredged material at a higher elevation, several hundred feet above the beach area used by the few loafing Caspian terns and DCCOs that have occupied the island. Rice Island is a former major colony site for both DCCO and Caspian terns and a likely area for DCCO dissuaded from East Sand Island to attempt to nest. Miller Sands and Pillar Rock Island were also designated critical habitat, and these areas were identified as potential DCCO dispersal locations and potential locations for hazing (see Table 2-3). At East Sand Island, anecdotal reports of streaked horned larks occurring on the island have been made, but no record of these observations exists. There were no observations of streaked horned larks from field crews present on East Sand Island during the 2010-2013 nesting seasons (March-July), and East Sand Island was not designated critical habitat for the species.

Black Oystercatcher *(Haematopus bachmani)*

Black Oystercatchers occur uncommonly along the North American Pacific coast from the Aleutian Islands to Baja California. Survey data are sparse, but the global population is approximately 10,000 individuals, making it one of the least abundant shorebird species in North America (Tessler et al. 2010). The majority (approximately 65 percent) of the global population resides in Alaska, and the species is most abundant from Alaska to southern British Columbia (Tessler et al. 1010). In the Salish Sea, an estimated 210 breeding pairs nested in 2005–2006 and breeding and wintering abundance has been either stable or increasing (Crewe et al. 2012). Black oystercatchers forage exclusively on intertidal macroinvertebrates (i.e., mussels and limpets predominantly) and nest in low densities. In Washington, black oystercatchers occasionally nest on gravel beaches on offshore islands, but there are few nests found on gravel in Oregon or California (Tessler et al. 2010).

Cassin's Auklet *(Ptychoramphus aleuticus)*

Cassin's auklets breed in natural crevices or burrows along the coast. The global population is estimated to be 3.6 million breeding individuals, with the core of the population breeding in British Columbia. The Pacific Region (Washington, Oregon, California) includes less than 5 percent of the global population. In Washington, the breeding population is approximately 87,600 individuals, with the majority breeding on Alexander Island (approximately 54,600 individuals). In Oregon, there are an estimated 500 breeding individuals. The largest breeding colony (approximately 20,000 individuals) in California is on the Farallon Islands, which is the southernmost boundary of the affected environment. Population declines have been documented at many breeding colonies throughout the species' range (USFWS 2005b).

Rhinoceros Auklet *(Cerorhinca monocerata)*

There are approximately 1 million breeding individuals within the North American population of rhinoceros auklets, and distribution is primarily concentrated along the coasts of southeast Alaska, British Columbia, and northern Washington. There are two major breeding colonies in Washington that support approximately 50,000 breeding individuals: Destruction Island along the coast and Protection Island in the Salish Sea; both are National Wildlife Refuges (USFWS 2005b). In Oregon, there are approximately 1,000 breeding individuals along the coast. Rhinoceros auklets have re-colonized areas in California where the breeding population is estimated to be approximately 2,000 individuals (USFWS 2005b). Breeding abundance declines at Protection Island and wintering abundance declines in the Salish Sea have been observed, although monitored breeding colonies elsewhere in British Columbia have been stable or increasing (USFWS 2005b; Crewe et al. 2012). Recent surveys documented 36,152, 1,546, and 6,494 occupied Rhinoceros Auklet burrows on Protection, Smith, and

Destruction Islands, a 52 percent increase in abundance in the Salish Sea from the 1970s and 1980s, and a 60 percent decrease at Destruction Island since 1975 (Pearson et al. 2013).

Common Murre *(Uria aalge)*

U. a. californica is the recognized sub-species that breeds in California, Oregon, and Washington, and this population is estimated to be approximately 1 million breeding individuals. The majority of the breeding population is in Oregon (approximately 712,000 individuals) and California (approximately 352,000 individuals), and abundance in these areas is stable or increasing (USFWS 2005b). Washington has approximately 7,000 breeding individuals (USFWS 2005b). Decreases in wintering abundance in the Salish Sea have been observed; there are no known breeding colonies in this area (Crewe et al. 2012).

Fork-tailed Storm-Petrel *(Oceanodroma frucata)*

Fork-tailed Storm-Petrels breed widely throughout the north Pacific, and the core of the breeding population resides in Alaska. Global populations and trends are unclear because of sparse data, due to nocturnal attendance at colonies and burrowing or crevice-nesting habits. There are an estimated 5,000 breeding individuals in Washington (approximately 3,900), Oregon (approximately 500), and California (approximately 400), which represents approximately less than 1 percent of the North American population.

Leach's Storm-Petrel *(Oceanodroma leucorhoa)*

Leach's storm-petrels breed widely throughout the Pacific. The estimated global population is more than 16 million breeding individuals, although estimates and trends are unclear because of sparse data due to nocturnal attendance at colonies and burrowing or crevice-nesting habits. There are an estimated 450,000 breeding individuals in Washington (approximately 36,000), Oregon (approximately 435,000), and California (approximately 12,500), which represents approximately 3 percent of the global population (USFWS 2005b).

Pigeon Guillemot *(Cepphus columba)*

Pigeon guillemots breed widely throughout the Pacific. The estimated global and North American populations are approximately 246,000 and 88,000 breeding individuals, respectively. There are five recognized sub-species, two of which breed in the Pacific Region: *C. c. adianta* (British Columbia and Washington) and *C. c. eureka* (Oregon and California). There are an estimated 38,000 breeding individuals within Washington (approximately 18,000), Oregon (approximately 4,500), and California (approximately 15,500), which represents approximately 40 percent of the North American population (USFWS 2005b). Population trends are largely unknown due to sparse data. However, new breeding colonies have become established in the southern portion of the species' range (USFWS 2005b), and increases in winter abundance in the Salish Sea and coastal British Columbia have been documented (Bower 2009; Crewe et al. 2012).

Tufted Puffin (*Fratercula cirrhata)*

The estimated Tufted puffin global population is 3 million breeding individuals, of which less than 1 percent are located in Washington, Oregon, and California. The majority (approximately 95 percent) of the North American population resides in Alaska. Estimates and trends are unclear because of sparse data due to burrowing or crevice-nesting habits, but breeding populations in the past decades appear to have increased in the Gulf of Alaska and westward and declined throughout southeast Alaska, British Columbia, Washington, Oregon, and California (USFWS 2005b).

In Washington, abundance decreased from approximately 23,000 breeding individuals in the 1980s to several thousands in recent years, and there was an estimated 60 percent decrease in occupancy of historic breeding sites during the past 25 years (approximately 50 percent in the Salish Sea; WDFW 2012). In Oregon, approximately 66 percent of tufted puffins bred at Three Arch Rocks NWR, which supported approximately 2,000 to 4,000 breeding individuals in the early 2000s. However, this colony is on the decline and only 200 breeding individuals were observed in 2013 (USFWS 2014b). The largest colony is now at Haystack Rock (USFWS 2014b). A few hundred individuals breed in California (Shuford and Gardali 2008). On February 11, 2014 the National Resources Defense Council petitioned the USFWS to list the tufted puffin under the ESA in California, Oregon and Washington, citing impacts from climate change, fish nets, oil spills, and declines in marine forage fish availability (NRDC 2014).

Great Blue Heron, Pacific sub-species *(Ardea herodias fannini)*

Great blue herons are a very common species with a wide distribution across most of North America. They are obligate tree nesters. Pacific great blue herons are a sub-species, distributed along the Pacific Coast from Prince William Sound, Alaska south to Puget Sound, Washington, and reside within this range year-round. Total population is approximately 9,500 to 11,000 breeding individuals, with approximately 4,000 to 5,000 breeding individuals in British Columbia. Population declines since the 1970s have been documented (COSEWIC 2008).

3.2.5 ESA-Listed Fish

ESA-listed listed fish species were chosen as the focus of analyses because they are the underlying focus of conservation efforts related to RPA actions in the FCRPS Biological Opinion. Due to their critical conservation status, ESA-listed species have the potential to be most seriously impacted by proposed alternatives. In many instances, data are often more readily available for ESA-listed species compared to other species, which provides a more robust and meaningful analysis. Additionally, the distribution of ESA-listed fish species and range of critical habitat overlaps areas where state-listed or other fish species are present. Thus, analyses of ESA-listed fish species adequately provide information for other species that could be impacted by DCCO predation in those areas.

This section is further narrowed down to address ESA-listed fish within sub-regions of the affected environment (i.e., the Lower Columbia River Basin, Oregon Coast, Washington Coast, Salish Sea, and Vancouver Island Coast). Several fish species protected by the ESA occur within the sub-regions identified in Chapter 3 and are potential prey for DCCOs dispersed from East Sand Island, due to the proposed alternatives considered in the EIS (Table 3-4).

TABLE 3-4. ESA-listed Fish Species that Occur within the Sub-regions of the Affected Environment. ESA Status (Threatened [T], Endangered [E]) of Each Species or Distinct Population Segment (DPS) is provided.

Species - *ESU, DPS*	**ESA-Status**	**Presence in Sub-Regions of Affected Environment**
Bocaccio rockfish	Endangered	Salish Sea
Bull trout	Threatened	Salish Sea/Washington Coast/Lower Columbia River
Canary rockfish		
Puget Sound/Georgia Basin	Threatened	Salish Sea
Chinook salmon		
Lower Columbia River	Threatened	Lower Columbia River
Snake River Fall-run	Threatened	Lower Columbia River
Snake River Spring/Summer-run	Threatened	Lower Columbia River
Upper Columbia River Spring-run	Endangered	Lower Columbia River
Upper Willamette River	Threatened	Lower Columbia River
Puget Sound	Threatened	Salish Sea
Chum salmon		
Columbia River	Threatened	Lower Columbia River
Hood Canal	Threatened	Salish Sea
Coho salmon		
Lower Columbia River	Threatened	Lower Columbia River
Oregon Coast	Threatened	Oregon Coast
Southern OR/Northern CA	Threatened	Oregon Coast
Pacific eulachon	Threatened	Salish Sea/Washington Coast/Lower Columbia River /Oregon Coast
Sockeye salmon		
Ozette Lake	Threatened	Washington Coast
Snake River	Endangered	Lower Columbia River
Steelhead		
Lower Columbia River	Threatened	Lower Columbia River
Middle Columbia River	Threatened	Lower Columbia River
Snake River Basin	Threatened	Lower Columbia River
Upper Columbia River	Threatened	Lower Columbia River
Upper Willamette River	Threatened	Lower Columbia River
Puget Sound	Threatened	Salish Sea
Yelloweye rockfish	Threatened	Salish Sea

Overview of Fish in the Affected Environment

The majority of ESA-listed fish species in the sub-regions of the affected environment belong to the salmon and trout family, *Salmonidae.* Pacific salmon and trout are an important biological, cultural, and economic resource in the Pacific Northwest. Many populations have been declining since the late nineteenth century, with documented losses to harvest, habitat degradation, hydropower development, and other anthropogenic causes (Gresh et al. 2000; Lichatowich 2001; NOAA 2014a). More recently, avian predation has been identified as a factor limiting the recovery of ESA-listed salmonid populations in the Columbia River Basin (see Section 2.6). Before industrialized development occurred, numbers of adult salmon in the Columbia River Basin were estimated to be around 10 to 16 million adult fish per year (Gresh et al. 2000). Currently, less than two million adult salmon return to the Columbia River Basin annually (FPC 2014).

The maximum sized fish a DCCO can consume depends on the mass and shape of the fish, but is generally no greater than about 17 inches (Hatch and Weseloh 1999; BRNW unpublished data). Thus, predation concerns are primarily associated with the consumption of juvenile-sized fish, as most adult-size fish, particularly anadromous salmonids, exceed 17 inches in length (Groot and Margolis 1991). Anadromous salmonids generally exhibit two principal life history types: stream- and ocean-type. Stream-type salmonids typically rear in fresh water for a year or more (referred to as "yearlings") before beginning their downstream migration to the ocean. Ocean-type salmonids typically migrate downstream within days to months following hatching (referred to as "subyearlings"). Both life history types, stream and ocean, are susceptible to DCCO predation. The run-timing and abundance of fish that exhibit these life histories, however, can vary substantially by species, population, and location (Groot and Margolis 1991).

The southern DPS of Pacific eulachon (*Thaleichthys pacificus*), which ranges from the Mad River in California to the Elwha River in Washington, were ESA-listed in 2011. Similar to ocean-type salmonids, these anadromous fish migrate to the ocean shortly after hatching. Unlike most anadromous salmonids, however, both juvenile and adult Pacific eulachon are susceptible to cormorant predation due to the small size of adult eulachon (approximately 9 inches), compared to adult salmonids. Known threats to Pacific eulachon recovery include habitat loss and degradation, hydroelectric dams and dam operations, and adverse environmental conditions (NOAA 2014a).

Three species of rockfish (bocaccio [*Sebastes paucispinis*], canary rockfish [*Sebastes pinniger*], and yelloweye rockfish [*Sebastes ruberrimus*]) found in the Salish Sea sub-region were ESA-listed in 2010. These species are strictly found in marine waters. Adult rockfish are generally found in deep water (greater than 80 feet) and are often too large to be consumed by DCCOs. Juvenile rockfish, however, are known to inhabit shallower water near kelp beds, rocky tidal areas, and other structures where they could potentially be susceptible to DCCO predation. Known threats to bocaccio, canary, and yelloweye rockfish include direct harvest, by-catch in commercial fisheries, and adverse environmental conditions (NOAA 2014a). A more detailed description of the list history, distribution, and potential impact of DCCO predation on ESA-listed fish within the sub-regions of the affected environment is presented in Sections 3.2.6 and 3.2.7.

3.2.6 ESA-listed Fish in the Lower Columbia River Basin

Six fish species, representing fifteen different ESA-listed ESUs or DPSs, occur in the Lower Columbia River Basin and are potential prey to DCCOs within the sub-regions of the affected environment. Many of these fish populations originate upstream of the Lower Columbia River Basin but use the Lower Columbia River during the migratory portion of their life. Because DCCO predation primarily affects small fish, information presented in this section focuses on the juvenile life stage of each ESA-listed fish species or ESU or DPS.

Data regarding DCCO impacts to ESA-listed fish in the Lower Columbia River Basin are primarily based on studies conducted by Bird Research Northwest (BRNW) at the East Sand Island DCCO colony, including an analysis of juvenile salmonid consumption based on DCCO diet samples and bioenergetics modeling and ESU or DPS-specific predation rates (number consumed divided by number available) based on recoveries of salmonid PIT tags. Empirical data, however, is not available for all ESA-listed ESU or DPS salmonid groups that occur in the Lower Columbia River Basin. Where data are available, it is provided. For those species lacking empirical data, potential impacts are primarily based on spatial or temporal overlap with the DCCO nesting season at East Sand Island and critical habitat designations for ESA-listed fish in the Lower Columbia River Basin.

Bull Trout (*Salvelinus confluentus*)
This DPS includes all bull trout within the contiguous United States (USFWS 2014a). Bull trout in the Columbia River Basin exhibit a resident, fluvial (migration between different streams or rivers), and adfluvial (migration between streams and lakes) life history. Use of the Columbia River Estuary by bull trout is believed to be minimal because bull trout from the Columbia River Basin are not anadromous (USFWS 2014a). Adult bull trout spawn in late summer to late fall (August to November) and reach maturity at 4 to 7 years of age (USFWS 2014a). Fish can live to be 12 years of age. Size at maturity varies by location and life history (migratory versus resident), but is generally between 12 and 20 inches, with fish greater than 30 inches and 30 lbs observed (USFWS 2014a). PIT tags implanted in juvenile and sub-adult bull trout have been detected on a DCCO colony located in the middle Columbia River (Roby et al. 2013); however, bull trout PIT tags have not been recovered on the East Sand Island DCCO colony, nor have bull trout been identified in DCCO diet samples. As such, there is no evidence that DCCOs nesting on East Sand Island have consumed bull trout in the Lower Columbia River Basin to date.

Lower Columbia River Chinook Salmon (*Oncorhynchus tshawytscha*)
This ESU includes all naturally spawned populations of Chinook salmon from the mouth upstream to the Hood River and the White Salmon River, including the Willamette River to Willamette Falls, Oregon

(NOAA 2011a). Select hatchery stocks are also included in the ESU. Juveniles typically out-migrate to the ocean in the spring (April-June) as yearlings or in late spring to summer (June-August) as subyearlings. Numerically, hatchery-reared subyearlings dominate the juvenile population, with between 50 and 100 million subyearlings released annually into the Lower Columbia River Basin since the 1990s (NOAA 2011a). Based on a small number of PIT-tagged lower Columbia River hatchery Chinook, annual predation rates by DCCOs nesting on East Sand Island averaged 26 percent (ranging = 4-40 percent) of available fish during 2007-2010 (Lyons et al. 2014), representing some of the highest salmonid predation rates documented. Data indicate that hatchery stocks released in close proximity to East Sand Island and subyearling Chinook were the most vulnerable to DCCO predation in the Columbia River Estuary (Sebring et al. 2013). Due to a lack of wild Chinook PIT-tagging and the disproportionate tagging of fish in close proximity to East Sand Island, however, it is unknown how representative these predation rate estimates are to all Chinook from the Lower Columbia River ESU (Lyons et al. 2014).

Diet composition data collected from DCCO nesting on East Sand Island also indicate that subyearling Chinook are particularly vulnerable to cormorant predation, with average annual consumption estimates of 7.8 million (range = 1.9-15.6) subyearling Chinook during 2004-2013. Although this estimate includes subyearling Chinook from all Columbia River Basin populations (Lower Columbia River, Snake River, Upper Columbia River, and others combined), genetic analysis indicates that the majority (ca. 70 percent) of sub-yearling Chinook consumed by DCCOs originate from the Lower Columbia River ESU (Roby et al. 2014).

Snake River Fall-run Chinook Salmon

This ESU includes all naturally spawned fall-run Chinook salmon in the lower Snake River and in lower reaches of the Tucannon River, Grande Ronde River, Imnaha River, Salmon River, and Clearwater River sub-basins (NOAA 2011a). Select hatchery stocks are also included in the ESU. Juveniles out-migrate during the spring as yearlings or in late spring to early fall (June – September) as sub-yearlings (Keefer and Peery 2008). Predation rates by DCCO nesting on East Sand Island indicate that an average of 3 percent (ranging = 2-5 percent) of available Snake River fall-run Chinook smolts were annually consumed by DCCOs during 2004-2013.

Snake River Spring/Summer-run Chinook Salmon

This ESU includes all naturally spawned populations of spring/summer-run Chinook salmon in the mainstem Snake River and the Tucannon River, Grande Ronde River, Imnaha River, and Salmon River sub-basins (NOAA 2011a). Select hatchery stocks are also included in the ESU. Snake River spring/summer-run Chinook salmon out-migrate in the spring as yearlings. Predation rates by DCCO nesting on East Sand Island indicate that an average of 4 percent (ranging = 2-7 percent) of available Snake River spring/summer Chinook smolts were annually consumed by DCCOs during 2004-2013.

Upper Columbia River Spring-run Chinook Salmon

This ESU includes all naturally spawned populations of spring-run Chinook salmon in tributaries upstream of Rock Island Dam and downstream of Chief Joseph Dam in Washington State (NOAA 2011a). Select hatchery stocks are also included in the ESU. Upper Columbia River spring-run Chinook are one of two ESA-listed Columbia River Basin salmonid populations designated as endangered (the other being Snake River sockeye), and they are considered to be at a high risk of extinction (NOAA 2011a). Upper Columbia River spring-run Chinook salmon out-migrate during the spring as yearlings. Predation rates by DCCO nesting on East Sand Island indicate that an average of 4 percent (ranging = 2-6 percent) of available Upper Columbia River spring-run Chinook smolts were annually consumed by DCCOs during 2004-2013.

Upper Willamette River Chinook Salmon

This ESU includes all naturally spawned spring-run Chinook salmon in the Clackamas River and in the Willamette River and its tributaries, above Willamette Falls, Oregon (NOAA 2011a). Select hatchery stocks are also included in the ESU. Upper Willamette River Chinook salmon out-migration times vary considerably compared to other ESA-listed salmonid populations in the Columbia River Basin, with fish out-migrating nearly year round (FPC 2014). Peak out-migration generally occurs in the spring as yearlings. Predation rates by DCCO nesting on East Sand Island indicate that an average of 2 percent (ranging = 1-4 percent) of available Upper Willamette River Chinook smolts were annually consumed by DCCOs in the Columbia River Estuary during 2007-2013.

Columbia River Chum Salmon *(O. keta)*

This ESU includes all naturally spawned chum salmon in the Columbia River and its tributaries in Oregon and Washington (NOAA 2011a). Select hatchery stocks are also included in the ESU. Although all naturally spawned chum salmon found in the Columbia River are included in the ESU, the vast majority of Columbia River chum originate in streams located downstream of Bonneville Dam (NOAA 2011a). Chum salmon fry out-migrate shortly after emergence in late winter to spring (March-May). Juvenile chum salmon may reside and feed in the Upper or Lower Columbia River Estuary before entering the open ocean (Groot and Margolis 1991). There are no PIT tag-based predation rate estimates available for Columbia River chum. Diet composition data from DCCO nesting on East Sand Island indicate that chum salmon are rarely consumed, however, with only one juvenile salmonid genetically identified as a chum salmon out of 451 samples tested (Lyons et al. 2014). Consequently, impacts to Columbia River chum salmon from DCCOs nesting on East Sand Island were likely minimal, although data regarding ESU-specific predation rates are lacking.

Lower Columbia River Coho Salmon *(O. kisutch)*

This ESU includes all naturally spawned populations of coho salmon in the Columbia River and its tributaries, from the mouth up to and including the Big White Salmon River and Hood River and up the Willamette River to Willamette Falls, Oregon (NOAA 2011a). Select hatchery stocks are also included in the ESU. Lower Columbia River coho out-migrate during the spring as yearlings. Similar to other ESA-listed salmonid populations that originate in the Lower Columbia River Basin, the majority of coho from this ESU are found in streams located downstream of Bonneville Dam. Based on the limited number of coho PIT-tagged downstream of Bonneville Dam, predation rates by DCCOs nesting on East Sand Island on juvenile coho averaged 28 percent (range = 10-30 percent) of the available fish during 2007-2010 (Lyons et al. 2014), representing some of the highest salmonid predation rates documented. Few wild coho, however, were PIT-tagged, and estimates were based predominately on select groups of hatchery fish released in close proximity to East Sand Island (Lyons et al. 2014). Diet composition data collected from DCCOs nesting on East Sand Island also indicate that juvenile coho are particularly vulnerable to DCCO predation in the Columbia River Estuary, with average annual consumption estimates of 2.4 million (range = 0.3-4.8) smolts during 2004-2013. Although this estimate includes coho from all populations or stocks combined, genetic analysis indicate that the majority (ca. 80 percent) of coho found in DCCO diet samples originated from the Lower Columbia River ESU (Roby et al. 2014).

Pacific Eulachon

This DPS includes eulachon from the Mad River in northern California to the Elwha River in Washington, an area referred to as the southern DPS (NOAA 2014a). Pacific eulachon are small (maximum length approximately 9 inches), anadromous fish (NOAA 2014a). The Columbia River and its tributaries are believed to support the largest eulachon runs in the southern DPS (NMFS 2011b). Although little is known about the movement of larvae and juvenile eulachon, they are believed to move quickly through the estuary (weeks), are widely distributed in the ocean, and are typically found in deep water (60 to 450 feet; NOAA 2011b). In the Columbia River, adult eulachon return to spawn in late winter to early spring (February to early April; NOAA 2011b). Due to their small size, eulachon are susceptible to DCCO predation throughout their entire life cycle. There is very little temporal overlap, however, between the DCCO nesting season (April to September) and the adult eulachon spawning run. Furthermore, eulachon (juveniles or adults) have not been identified in East Sand Island DCCO diet samples, so the impact of nesting DCCO on eulachon in the Lower Columbia River Basin is presumed to be minimal. The impact of non-breeding birds or breeding birds that arrive in the Columbia River Estuary before the nesting season, however, is unknown. There are no PIT tag-based predation rate estimates available for Pacific eulachon.

Snake River Sockeye Salmon *(O. nerka)*

This ESU includes all anadromous sockeye from the Snake River Basin, Idaho, as well anadromous and residual sockeye salmon (referred to as kokanee) from Redfish Lake, Idaho (NOAA 2011a). One hatchery stock, from the Redfish Lake Captive Program, is included in the ESU. Snake River sockeye are one of two Columbia River Basin salmonid populations designated as endangered (the other being Upper Columbia River spring-run Chinook), and although adult return numbers have recently improved, they are still considered to be at a high risk of extinction (NOAA 2011a). Anadromous juvenile Snake River sockeye out-migrate in the spring as yearlings. Predation rates by DCCO nesting on East Sand Island indicate that an average of 4 percent (ranging = 3-6 percent) of available anadromous Snake River sockeye smolts were annually consumed by DCCOs during 2009-2013.

Lower Columbia River Steelhead *(O. mykiss)*

This DPS includes all naturally spawned steelhead populations below impassable barriers in streams and tributaries of the Columbia River between the Cowlitz and Wind Rivers, Washington, the Willamette River to Willamette Falls, Oregon, and the Hood River, Oregon (NOAA 2011a). Select hatchery stocks are also included in the DPS. Juvenile Lower Columbia River steelhead out-migrate as yearlings in the spring. There are no PIT tag-based predation rate estimates available for this DPS. Smolt consumption estimates based on diet composition data are also lacking. Predation rate data from other steelhead DPSs (those originating entirely upstream of Bonneville Dam) indicate that juvenile steelhead are susceptible to DCCO predation in the Columbia River Estuary, with average annual predation rates ranging from 2 to 17 percent (depending on the DPS and year). Since data from other salmonid ESUs or DPSs indicate that fish that originate or are released in close proximity to East Sand Island may be particularly vulnerability to DCCO predation, it is possible that impacts to Lower Columbia River steelhead are greater than those implied by predation rate estimates on Middle Columbia River, Upper Columbia River, and Snake River steelhead (see below).

Middle Columbia River Steelhead

This DPS includes all naturally spawned steelhead populations from above the Wind River, Washington, and the Hood River, Oregon, upstream to, and including, the Yakima River, Washington (NOAA 2011a). Select hatchery stocks are also included in the DPS. Lower Columbia River steelhead out-migrate as yearlings in the spring. Predation rates by DCCOs nesting on East Sand Island indicate that an average of 8 percent (ranging = 2-15 percent) of available Middle Columbia River steelhead smolts were annually consumed by DCCOs during 2007-2013.

Snake River Steelhead

This DPS includes all naturally spawned steelhead populations in streams in the Snake River Basin in Washington, Oregon, and Idaho (NOAA 2011a). Select hatchery stocks are also included in the DPS. Snake River steelhead out-migrate as yearlings in spring. Predation rates by DCCOs nesting on East Sand Island indicate that an average of 8 percent (ranging = 3-17 percent) of available Snake River steelhead smolts were annually consumed by DCCOs during 2004-2013.

Upper Columbia River Steelhead

This DPS includes all naturally spawned steelhead populations below impassable barriers in streams in the Columbia River Basin upstream from the Yakima River, Washington, to the United States-Canada border (NOAA 2011a). Select hatchery stocks are also included in the DPS. Upper Columbia River steelhead out-migrate as yearlings in the spring. Predation rates by DCCO nesting on East Sand Island indicate that an average of 6 percent (ranging = 3-11 percent) of available Upper Columbia River steelhead smolts were annually consumed by DCCOs during 2004-2013.

Upper Willamette River Steelhead

This DPS includes all naturally spawned winter-run steelhead populations in the Willamette River, Oregon, and its tributaries upstream from Willamette Falls to the Calapooia River, Oregon (NOAA 2011a). Hatchery stocks are not included in the DPS. Upper Willamette River steelhead out-migrate as yearlings in the spring. There are no PIT tag-based predation rate estimates or smolt consumption estimates available for this DPS, but it is reasonable to assume DCCO predation on Upper Willamette River steelhead is roughly comparable to that of other steelhead DPSs that originate upstream of the Lower Columbia River Basin (Middle Columbia River, Upper Columbia River, and Snake River basins), ranging from 2 to 17 percent of available fish per year.

3.2.7 Other ESA-listed Fish

Ten fish species, representing eleven different ESA-listed ESUs or DPSs, occur in regions other than the Lower Columbia River Basin and are potential prey to DCCOs within the sub-regions of the affected environment. Bull trout and Pacific eulachon were addressed in Section 3.2.6, but also occur in areas other than the Lower Columbia River Basin. A separate description for these two species is provided herein. It is important to note that many of the ESA-listed fish described in the EIS are anadromous or marine species, and, as such, they may occur in several different regions during their life cycle.

Empirical data regarding DCCO predation on ESA-listed fish outside of the Lower Columbia River Basin are generally lacking. With the exception of a few temporally limited studies within a few Oregon Coast estuaries, little to no empirical data are available to estimate rates of DCCO predation on these fish species. Where data are available, it is provided. When it is not available, the potential for DCCO to impact ESA-listed fish is primarily based on the spatial and temporal overlap between DCCOs in each sub-region and critical habitat designations of ESA-listed fish within those sub-regions. Similar to Chapter 3, section 3.2.6, discussion is focused on the juvenile life stage of each ESA-listed ESU or DPS (with the exception of Pacific eulachon) and assumes predation takes place within the sub-region of interest.

Bocaccio Rockfish

This DPS includes fish within the Puget Sound and Georgia Basin (NOAA 2013), the eastern section of the Salish Sea sub-region. Rockfish have internal fertilization and bear live young (viviparous). Following birth, larvae are found close to the surface in pelagic waters (NOAA 2013). Larvae and juveniles then temporarily settle in nearshore shallow water habitat before moving to deep water (50 to 750 feet; NOAA 2013), below the foraging depth reported for DCCOs (Hatch and Weseloh 1999). Based on their use of deep water habitat and large size at reproduction (typically more than 16 inches), interactions between bocaccio and DCCOs in the Salish Sea sub-region are likely minimal, although larvae and juveniles may be susceptible to DCCO predation.

Bull Trout

This DPS includes all bull trout within the contiguous United States (USFWS 2014a). Bull trout that occur in streams along the Washington Coast and Salish Sea sub-regions exhibit a resident, fluvial, adfluvial, and anadromous life history (USFWS 2014a). Migratory bull trout typically leave natal streams as juveniles or sub-adults. Bull trout reach maturity when they are 4 to 7 years of age and spawn in late summer to late fall (USFWS 2014a). Fish can live to be 12 years of age. Size and maturity varies by location and life history (migratory versus resident), but is generally between 12 and 20 inches, with fish greater than 30 inches and 30 lbs observed (USFWS 2014a). Bull trout susceptibility to DCCO predation may be greater for migratory fish compared with resident fish, especially for bull trout that utilize estuaries.

Canary Rockfish

This DPS includes fish within Puget Sound and Georgia Basin (NOAA 2013), the eastern section of the Salish Sea region. Similar to bocaccio, larvae canary rockfish are pelagic and then move to nearshore rocky areas to rear as juveniles (NOAA 2013). Juvenile canary rockfish are typically found in water 40 to 60 feet deep, but may use shallower water, particularly at night (NOAA 2013). Sub-adults and adults then move to deep water (more than 100 feet), outside the foraging depth reported for DCCOs (Hatch and Weseloh 1999). Based on their use of deep water habitats and the large size of fish at reproduction (more than 16 inches), interactions between canary rockfish and DCCOs in the Salish Sea sub-region are likely minimal, although larvae and juvenile canary rockfish may be susceptible to DCCO predation.

Puget Sound Chinook Salmon

This ESU includes all naturally spawned Chinook salmon from rivers and streams flowing into Puget Sound, including westward along the Strait of Juan de Fuca to the Elwha River and north along the Strait of Georgia in Washington (NOAA 2011a). Select hatchery stocks are also included in the ESU. Substantial variation occurs in the amount of time juvenile Chinook spend in freshwater and estuarine environments before entering the ocean. Most Puget Sound Chinook salmon out-migrate as subyearlings and may spend several months rearing in estuaries, including use of tidal marshes, dikes, and ditches. During their first ocean year, juvenile Puget Sound Chinook salmon can remain in nearshore marine habitats (NOAA 2011a). Extended use of estuaries and nearshore marine environments by juvenile Puget Sound Chinook suggests they could be vulnerable to DCCO predation.

Hood Canal Chum Salmon

This ESU includes all naturally spawned summer-run chum salmon in Hood Canal and its tributaries as well as those in the Olympic Peninsula rivers between Hood Canal and Dungeness Bay, Washington (NOAA 2011a). Select hatchery stocks are also included in the ESU. Hood Canal chum salmon out-migrate shortly after hatching as fry in late winter (February–March) and rear in deltas and estuaries, which support a diverse array of habitats (tidal channels, mudflats, marshes, and eelgrass meadows; NOAA 2011a). Juveniles remain in estuary and delta habitats for several weeks before entering the ocean. Similar to Puget Sound Chinook salmon, use of estuary and delta habitats by juvenile chum suggests they could be vulnerable to DCCO predation.

Oregon Coast Coho Salmon

This ESU includes all naturally spawned coho salmon in Oregon coastal streams south of the Columbia River and north of Cape Blanco, Oregon (NOAA 2011a). The hatchery stock from Cow Creek is included in the ESU. Juveniles out-migrate as yearlings in the spring. Adrean (2013) reported that DCCO foraging in Tillamook Bay, Oregon (critical habitat for Oregon Coast coho salmon) consumed an estimated 8,000 out-migrating coho smolts during the spring of 2012, which equates to approximately 4 percent of the hatchery and wild coho smolts available in the bay. Salmonids overall composed, on average, 35 percent of DCCO diet by biomass (Adrean 2013), indicating susceptibility of juvenile salmonids to DCCO predation in an Oregon estuary environment.

Southern Oregon/Northern California Coast Coho Salmon

This ESU includes all naturally spawned coho salmon in coastal streams between Cape Blanco, Oregon and Punta Gorda, California (NOAA 2011a). Select hatchery stocks are also included in the ESU. Juveniles out-migrate as yearlings in the spring. No empirical data to evaluate Southern Oregon/Northern California Coast coho predation by DCCOs in the Oregon Coast sub-regions is currently available. Data from Adrean (2013) and Clements et al. (2012), however, suggest that coho smolts along the northern Oregon Coast may be vulnerable to DCCO predation in estuary environments, and estuaries with DCCO colonies exist in this sub-region (e.g., Rogue River Estuary, Oregon).

Pacific Eulachon

This DPS includes eulachon from the Mad River in northern California to the Elwha River in Washington, an area referred to as the southern eulachon DPS. Eulachon larvae out-migrate to the ocean shortly after hatching and spend the majority (more than 95 percent) of their lives in the ocean (NOAA 2011b). Although little is known about the movement of larvae and juvenile eulachon, they are believed to be widely distributed in the ocean and are typically found in deep water (60 to 450 feet; NOAA 2011b). Along the Oregon and Washington Coast, adult eulachon return to spawn in late winter to early spring (NOAA 2011b). No empirical data to evaluate eulachon predation by DCCOs in the Oregon Coast, Washington Coast, and Salish Sea sub-regions currently exist. Due to their small size, eulachon are susceptible to DCCO predation throughout their life cycle. There is little temporal overlap, however, between the DCCO nesting season (April to September) and the eulachon spawning run, and juvenile eulachon may be too dispersed in the open ocean and deep in the water column to be susceptible to DCCO predation.

Ozette Lake Sockeye Salmon

This ESU includes all naturally spawned sockeye salmon in Ozette Lake, Washington and streams and tributaries connected to Ozette Lake. Two hatchery stocks, Umbrella Creek and Big River, are also part of the ESU (NOAA 2011a). Juveniles rear in Ozette Lake and out-migrate via the Ozette River as yearlings in the spring (NOAA 2011a). No empirical data to evaluate Ozette Lake sockeye predation by DCCOs along the Washington Coast sub-region exists. The out-migration timing and size of Ozette Lake sockeye, however, suggest they could be susceptible to DCCO predation, especially if juvenile sockeye reside or congregate in or near the Ozette River estuary or other habitats where DCCO dispersed from East Sand Island forage.

Puget Sound Steelhead

This DPS includes all naturally spawned steelhead in streams in the river basins of the Strait of Juan de Fuca, Puget Sound, and Hood Canal, Washington, bounded to the west by the Elwha River and to the north by the Nooksack River and Dakota Creek. Hatchery winter-run steelhead stocks from the Green River and Hamma Hamma are included in the DPS. Puget Sound steelhead out-migrate as yearlings in the spring. Little is known about estuary and nearshore marine habitat use following out-migration, but steelhead smolts are believe to move offshore more quickly as compared with Puget Sound Chinook and Hood Canal chum salmon (NOAA 2011a).

Yelloweye Rockfish

This DPS includes fish within Puget Sound and Georgia Basin (NOAA 2013), the eastern section of the Salish Sea sub-region. Compared with bocaccio and canary rockfish, juvenile yelloweye rockfish are typically found in deep water (around 100 feet; NOAA 2013), outside the foraging depth reported for DCCOs (Hatch and Weseloh 1999). Yelloweye rockfish are also considered solitary and are rarely found in groups or aggregations (NOAA 2013). Based on their presence in deep water for the vast majority of their lives, including the juvenile life stage, and the large size of fish at reproduction, interactions between yelloweye rockfish and DCCOs in the Salish Sea sub-region are likely minimal, although larvae fish may be susceptible to DCCO predation.

Areas of Specific Management Concern for ODFW and WDFW

While this section focused on ESA-listed species, it is important to note that during interagency DCCO working group meetings WDFW and ODFW were asked to assess specific areas of management concern based on the occurrence and status of fish populations of conservation concern (Figure 3-14). Areas were classified according to the following criteria: 1) areas of significant management concern could not tolerate formation of new DCCO colonies or increases in active colonies; 2) areas of moderate management concern could tolerate some increase in DCCO numbers if closely monitored; 3) areas of low management concern could tolerate larger increases in DCCO numbers if monitored.

During cooperating agency meetings on the development of the draft EIS, concerns from ODFW and WDFW over DCCO dispersal to areas of management concern were repeated. ODFW and WDFW identified much of their respective states as areas of some concern (Figure 3-14). ODFW specifically identified and expressed concern for coastal estuaries and lakes (Nehalem Bay, Tillamook Bay, Nestucca Bay, Alsea Bay, Siuslaw River, Umpqua River, Coos Bay, Coquille River, Rogue River, and the coastal lakes of Siltcoos, Tahkenitch, and Tenmile). ODFW has developed DCCO predation thresholds for the north, mid, and southern Oregon coast regions, based on a moving 3-year abundance average for each zone, and intends to manage coastal DCCO populations at those levels.

WDFW identified much of the southern coast and interior as areas of significant concern (Figure 3-14). Areas of low management concern identified by WDFW were along the north coast, including the Copalis River between Pacific Beach and Ocean City, Moclips River south of Point Grenville, Raft River north of Cape Elizabeth, Kalaloch Creek south of Destruction Island, Mosquito and Goodman creeks, both north of Hoh Head, Quillayute River near James Island, and the Sooes and Waatch rivers between Cape Flattery and Point of the Arches.

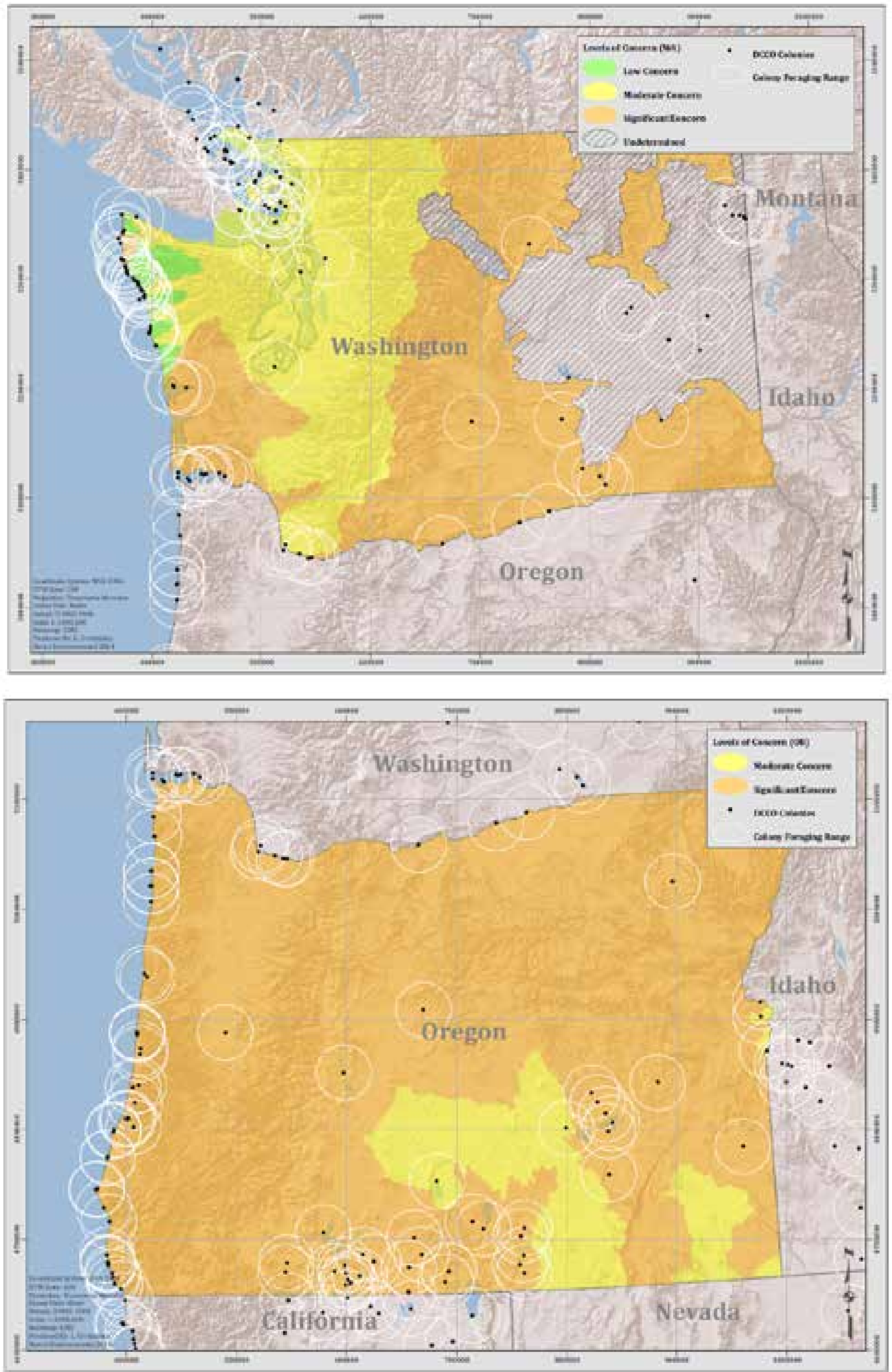


FIGURE 3-14. Map of Washington State (top) and Oregon State (bottom) depicting areas of specific management concern (red), areas of moderate management concern (orange), and areas of low management concern (green). Black dots identify DCCO breeding colonies at the time of the most recent surveys (1989-2010). Open circles delineate the expected foraging range (25 km radius) of DCCOs. Maps were created by ODFW and WDFW and may not represent all interested parties within the states.

3.3 Socioeconomic Environment

This section addresses the social and economic issues associated with DCCOs, with primary focus on Columbia River in-river fisheries (tribal, recreational, and commercial), public resources, and historic properties on East Sand Island. Columbia River in-river fisheries are defined as the regions wherever Columbia River Basin production contributes to in-river fisheries, which include the Columbia Basin ecological provinces for the Columbia Estuary, Lower Columbia, Columbia Gorge, Columbia Plateau, Columbia Cascade, Blue Mountain, and Mountain Snake (see Appendix I for a more complete description of the geographic area considered for Columbia River in-river fisheries). Several comments received from public scoping requested that the Corps address social and economic issues, including potential impacts that management actions may have on individual user groups and regional economies. Impacts to fisheries, which have an associated economic value, provide a more quantifiable economic metric, compared with the wide range of socioeconomic values that could be altered by EIS actions. Even fisheries, though, entail a wide range of non-market values, including cultural significance and heritage, job satisfaction and livelihood, and recreational experience, which cannot be quantified in pure dollar terms (TRG 2014). Additionally, all wildlife have some economic value with regard to sightseeing and recreation. In Oregon in 2011, there were about twice the participants and trip spending by wildlife watchers (1.4 million participants and $1.7 billion spending) as hunters (0.2 million participants and $0.2 billion spending) and anglers (0.6 million participants and $0.6 billion spending) combined (TRG 2014). Wildlife also have less quantifiable values, such as inherent value to ecosystems and social or spiritual value to user groups. Social value and human dimensions are important underlying issues with human-wildlife conflicts and these issues are addressed in Chapter 4.6.6.

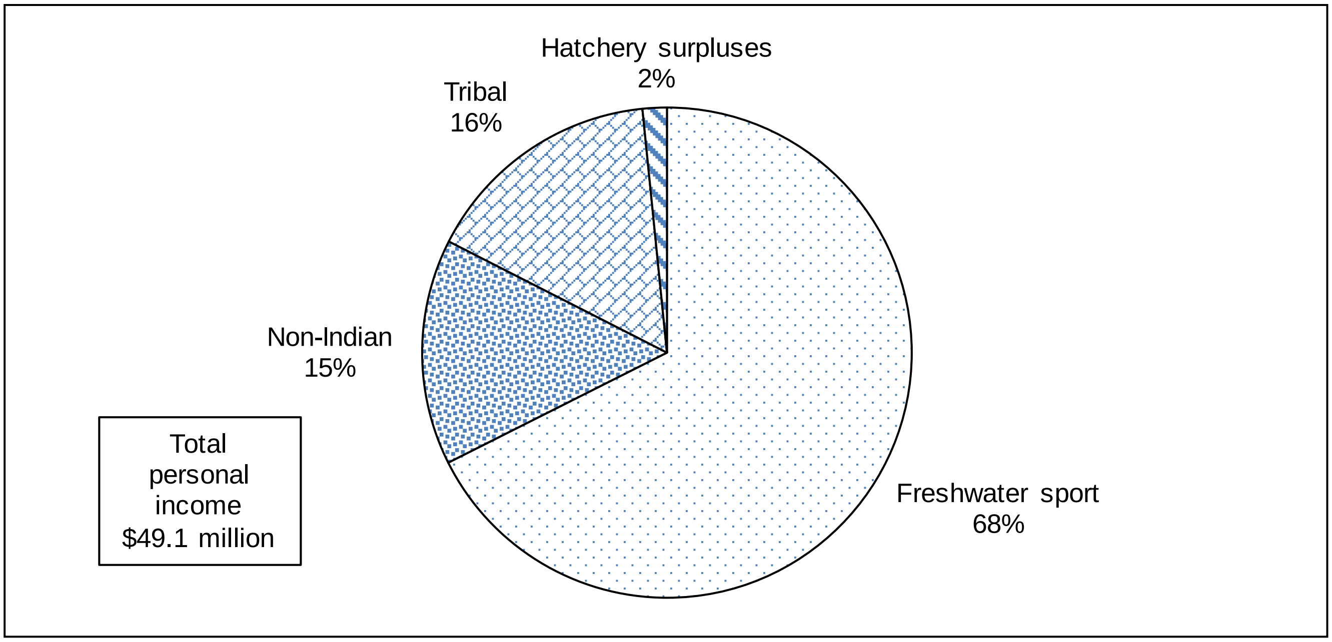
3.3.1 Columbia River Basin Salmon Fisheries

Because salmonids range over a large geographic area across a multitude of political boundaries, salmon production and harvest management is very complex. Five general governance processes give direction to salmonid production and harvest management. These include the: 1) Pacific Salmon Treaty, 2) Magnuson-Stevens Fisheries Conservation and Management Act, 3) Pacific Fisheries Management Council's Salmon Fishery Management Plan, 4) ESA-listed recovery stocks' harvest impact constraints, and 5) user group allocation agreements. Columbia River treaty tribes have authority to regulate treaty Indian fisheries. The ESA restricts the amount of wild salmon that may be harvested directly or indirectly once a species or sub-species has been placed on the threatened or endangered species list. Harvest managers must consult annually with NOAA Fisheries to ensure fishers are regulated to meet no-jeopardy standards established for ESA-listed salmonids. Columbia River fisheries are also regulated according to the Columbia River Fish Management Plan (2008-2017 agreement) adopted by the U.S. District Court order in 2008 and agreed to by the parties of U.S. v.

Oregon. The parties to U.S. v. Oregon are the United States, acting through the Department of the Interior (USFWS and Bureau of Indian Affairs) and the Department of Commerce (NOAA Fisheries), the Confederated Tribes of the Warm Springs Reservation of Oregon, the Confederated Tribes of the Umatilla Indian Reservation, the Nez Perce Tribe, the Confederated Tribes and Bands of the Yakama Nation, and the Shoshone-Bannock Tribes, and the states of Oregon, Washington, and Idaho. The Colville Confederated Tribes also have federally protected fishing rights on the Reservation, the former North Half, and the Wenatshapam fishery (see Antoine v. Washington, 420 U.S. 194 (1975); Colville Confederated Tribes v. Walton, 647 F.2d 42, 48 (9th Cir. 1981); United States v. Oregon, 606 F.3d 698 (9th Cir. 2010). Specifications for Colville Confederated Tribes harvest allocations are pursuant to a 2007 joint agreement between the Colville Confederated Tribes and WDFW.

Aside from Columbia River in-river and tributary fisheries, Columbia River Basin salmonid production contributes heavily to ocean fisheries from Oregon north to southeast Alaska, First Nation harvests in British Columbia, and other tribal, commercial, and personal use fisheries throughout this range. Although actions related to the EIS that improve juvenile salmonid survival in the Columbia River Estuary could have impacts to fisheries outside of the Columbia River Basin, focus is primarily limited to Columbia River Basin in-river fisheries and economies, as this is the area most likely affected by the proposed alternatives and the primary geographic focus concerning the EIS purpose and need. Additionally, EIS actions that result in redistribution of DCCOs could adversely affect fisheries in other areas.

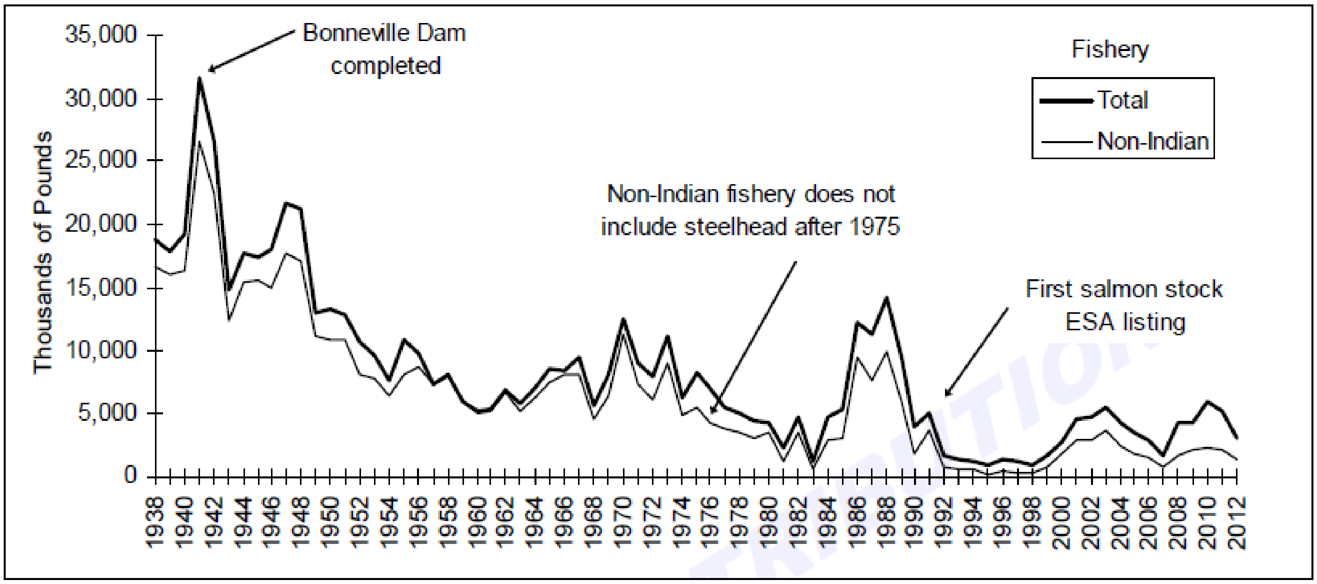
The Bonneville Dam separates the commercial gillnet fishery and commercial tribal fishery harvest areas. Commercial tribal fisheries are allowed below Bonneville Dam and in the Willamette River, if necessary, to attain seasonal fish allocations. Freshwater sport recreational fisheries include the popular fall season Buoy 10 fishery (west of Astoria, Oregon) as well as all other mainstem and tributary salmon and steelhead fisheries. An estimated $49.1 million in total personal income (2012 dollars) was generated from in-river fishery sectors, including hatchery surpluses (2 percent), tribal commercial (16 percent), non-Indian commercial (15 percent), and freshwater sport recreational fisheries (68 percent; Figure 3-15; TRG 2014). These different fisheries are discussed below in more detail.



*Includes minor economic contributions from business use of marketable hatchery returns. REI does not include economic contributions from hatchery operations.

FIGURE 3-15. Columbia River in-river fisheries regional economic impacts (REI) for current conditions in total personal income in 2012 dollars.

Long-term fisheries data are most comprehensive for in-river commercial fisheries, as compared to ocean or recreational fisheries. Trends in commercial fisheries are generally representative of the fisheries of the Columbia River as a whole. Trends show a precipitous decline in harvest, compared to harvest levels during the 1930s and 1940s, which ranged between 15 and 30 million pounds (Figure 3-16). Harvest levels were lowest during the 1990s and have rebounded to some extent. During 2008–2012, harvest levels were between 2.5 and 5 million pounds (Table 3-5). Converted to annual dollars during 2008–2012, this amount of commercial harvest in real market price value equaled from $6 to 11 million (Table 3-5).



*Weight is round pound equivalents; Sources: WDFW and ODFW (August 2004), Pacific Fishery Management Council (PFMC; February 2008), and TRG (2014).

FIGURE 3-16. Columbia River in-river fisheries commercial landings, total and non-Indian fisheries from 1938 to 2012.

TABLE 3-5. Columbia River In-river Fisheries Commercial Harvest Ex-vessel Price, Value, and Pounds during 2008–2012.

		Price					Ex-vessel Value (thousands)					Pounds (thousands)				
Fishery	Species	2008	2009	2010	2011	2012	2008	2009	2010	2011	2012	2008	2009	2010	2011	2012
TOTAL COLUMBIA RIVER (OREGON AND WASHINGTON)																
Non-treaty	Chinook															
Gillnet	Spring	6.71	5.07	5.16	5.03	5.92	1,093	791	2,526	1,548	1,386	163	156	490	308	234
	Fall	2.67	2.05	2.14	2.18	2.14	1,637	1,513	1,469	2,233	1,627	612	738	688	1,026	762
	Tules	0.61	0.57	0.62	0.59	0.54	68	95	160	138	110	112	168	257	234	204
	Coho	1.38	1.26	1.42	1.64	1.62	1,006	1,391	1,147	980	211	731	1,108	807	597	130
	Chum		0.00	1.00	1.00				3	1			1	3	1	
	TOTAL						3,804	3,790	5,305	4,900	3,334	1,618	2,171	2,245	2,166	1,330
Treaty	Chinook															
All gears	Spring	4.77	3.24	4.02	3.58	4.81	1,374	800	2,675	1,883	996	288	247	666	526	207
	Fall	1.75	1.13	1.31	1.93	1.84	2,692	1,456	2,280	3,566	2,054	1,538	1,283	1,747	1,849	1,117
	Tules	0.48	0.38	0.66	0.72	0.71	62	38	92	31	5	129	100	140	43	7
	Coho	0.92	0.73	1.36	1.46	1.38	210	51	57	268	47	228	70	42	183	34
	TOTAL						4,338	2,345	5,104	5,748	3,102	2,183	1,700	2,595	2,601	1,365
Columbia River Total							8,142	6,138	10,407	10,648	6,436	3,801	3,871	4,842	4,766	2,696

Notes: Dollars are adjusted to 2012 using the GDP implicit price deflator.
Source: PFMC, Review of Ocean Salmon Fisheries, annual in February.

Hatchery Production

Another important economic consideration in regard to Pacific salmonid fisheries is the importance of economic contributions that come from operating fishery enhancement and supplementation hatcheries. Smolt production costs can range from $1 to $2 per individual, depending on cost accounting inclusions (TRG 2014). Production of fall Chinook subyearlings (released at 25 to 50 per pound and comprising about 50 percent of all releases) are lesser, and production of steelhead yearlings (released at 8 to 12 per pound and comprising about 12 percent of all releases) are higher (TRG 2014). If hatchery production funding is considered exogenous money into a region, then the costs for labor, materials, administration, monitoring, and construction provide significant economic contributions, particularly to rural economies where the hatcheries are located. Depending upon returning hatchery origin adults goals and realized return levels, hatchery production can be altered, which could change funding levels (economic inputs) to a given area. Additionally, the area of production may not be the area in which economic returns (adult harvest) are received. Thus, there are complex positive and negative feedback loops with regard to adult salmonid abundance correlating to increases or decreases in regional or local economic effects.

Economic Impact of DCCO Predation

Juvenile salmonid consumption from DCCOs on East Sand Island was estimated to be as high as 20 million out-migrating smolt in recent years (Roby et al. 2014). Status quo conditions assume approximately half of the biomass is hatchery origin, but three-fourths of returning adults comprise the harvests. DCCO predation would represent a $21 million direct investment, assuming $1.50 per smolt release cost, all DCCO predation was curtailed, 30 percent passage mortality, no compensatory predation, and no predation rate differentiation in fish origin (TRG 2014). With regard to overall economic impacts to in-river Columbia River fisheries, The Research Group (2014) estimated that juvenile salmonid predation by DCCOs on the East Sand Island resulted in potential annual losses of $2.7 million (i.e., 6.5 percent of direct financial value and 5.5 percent of regional economic impact of Columbia River in-river fisheries; see Chapter 4, section 4.3.1 and Appendix I for a more detailed description and additional results from economic analysis).

3.3.2 Tribal Fisheries

Salmon are significant resources to tribes in the Pacific Northwest. Tribal cultures, economies, religion, and technologies have all been influenced by salmon. Columbia River tribes participate in commercial, ceremonial, and subsistence fisheries. Northwest Tribes celebrate the annual arrival of adult salmon coming back from the ocean in "First-Salmon" ceremonies. These ceremonies differ from tribe to tribe, but generally consist of honoring the annual return of salmon through ceremonies involved with the first salmon caught. The annual salmon harvest allows the transfer of traditional values from generation to generation. Salmon also serve to foster cultural values and cement social relationships within the community and with trading partners. Loss of access to salmon has had profound effects on the dietary habits and wellbeing of the Northwest Tribes (NOAA Fisheries 2008).

Tribal treaty fisheries on the Columbia River occur upstream of Bonneville Dam and include commercial, ceremonial, and subsistence fisheries. The four Columbia River Treaty Indian Tribes include the Bands of the Yakama Nation, Confederated Tribes of the Warm Springs Reservation of Oregon, Confederated Tribes of the Umatilla Indian Reservation, and the Nez Perce Tribe. Treaty Indian commercial catches became a larger portion of the total Columbia River commercial catches following the 1968 Federal court ruling regarding equitable Indian and non-Indian harvest sharing. Since 1968, commercial fishing in the area between Bonneville and McNary dams has been the exclusive province of the Treaty Indian Tribes. Colville Confederated Tribes members exercise federally protected fishing rights in the mainstem Columbia River between Chief Joseph Dam and the confluence with the Okanogan River, harvesting sockeye (n=4,276 in 2013), summer/fall Chinook (n=3,142 in 2013), and steelhead (n=127 in 2013), and harvesting spring Chinook on Icicle Creek (131 in 2012). Colville Confederated Tribes members harvest salmonids only for subsistence and ceremonial use and utilize a wide range of fishing gear, including the purse seine, hook and line, tangle-nets, beach seines, hoop and dip nets, and weirs.

Present-day treaty fisheries occur on the Columbia River and tributary locations and consist primarily of set gillnets, but dip net fishing and other methods are used. Tribal fisheries generally take place above Bonneville Dam, but other locations are sometimes used to fulfill treaty and trust responsibilities. Catch is allocated first for ceremonial purposes, next for subsistence (ceremonial and subsistence are sometimes considered together), and last for commercial purposes. No fish of any stock are sold for commercial purposes until ceremonial and subsistence needs are met. As recently as 1995, spring Chinook salmon were available for ceremonial purposes only. Fall Chinook salmon are routinely harvested for commercial sale. Total tribal harvest (including commercial, ceremonial, and subsistence) of spring and fall run salmon has averaged about 25,000 and 110,000 fish, respectively, during the early 2000 period (Mann 2004). Harvest for ceremonial and subsistence fisheries averaged approximately 14,500 fish per year during 2003–2012 (Table 3-6).

Subsistence fishing is permitted year-round in the mainstem Columbia River, unless closed by tribal regulation to meet management guidelines. Tribal harvests typically occur all year and include spring, summer, and fall Chinook, coho, and sockeye salmon, and summer and winter steelhead. Commercial salmon and steelhead fishing provides a means for continuing with parts of tribal historical lifestyle and represents a main source of livelihood for some tribal members. Columbia River tribes contribute greatly to the production of hatchery fish for the purposes of both harvest and conservation of Columbia River Basin salmonids. The following are the tribal hatchery facilities: Colville Tribes Cassimer Bar; Chief Joseph Hatchery; Cowlitz Salmon Hatchery; Confederated Tribes of the Umatilla Indian Reservation-Three Mile Dam Facility; Nez Perce Tribal Fish Hatchery; Yakama Nation Cle Elum Hatchery, Marion Drain Hatchery, Prosser Hatchery, and Klickitat Hatchery.

TABLE 3-6. Columbia River Tribal Ceremonial and Subsistence Harvests 1998–2012.

	High		Low			
	Amount	Year	Amount	Year	Mean	Median
Last 10 Years						
Coho	1,277	2003	22	2006	510	370
Spring/Summer Chinook	15,482	2012	6,435	2007	10,485	9,652
Fall Chinook	832	2012	15	2009	379	404
Steelhead	3,759	2005	1,596	2006	2,971	3,265

Notes:
1. The 10 year period is 2003 to 2012. Coho and steelhead central tendency analysis only inclusive of years 2003 to 2006. Year 2012 is preliminary.
2. Willamette River surplus hatchery fish have been used in some years to augment C&S harvests.
3. Chinook C&S are primarily mainstem fisheries between Bonneville and McNary dams. Significant subsistence fisheries also occur in tributaries throughout the Columbia and Snake River basin, especially for spring Chinook, which are not included in these estimates.

Sources: Chinook from PFMC (2013) and coho and steelhead from ODFW and WDFW (July 2007).

3.3.3 Recreational and Commercial Fisheries

Recreational Fisheries

Before 1975, lower Columbia River sport recreational fisheries focused primarily on salmon and steelhead harvest. Seasonal closures to protect declining salmonids transitioned much of the recreational fisheries to sturgeon. Recreational salmonid fishing efforts have rebounded with recent improvements in selective fishery opportunities. The lower Columbia River mainstem below Bonneville Dam is separated into two main areas for recreational harvest management: Buoy 10 (ocean/in-river boundary) to the Astoria-Megler Bridge, and the Astoria-Megler Bridge to Bonneville Dam. Columbia River tributary recreational fisheries occur throughout the lower Columbia. Depending on the time of year, different salmonids are targeted, including spring Chinook, summer steelhead, fall Chinook, coho, and winter steelhead. Detailed regulations are issued annually for time and area closures, bag limits, gear restrictions, and other techniques to keep total mortalities within the allocation and ESA-listed population impact schemes.

Commercial Fisheries

Columbia River commercial fisheries became important in the 1860s. Since the early 1940s, Columbia River commercial catches of salmon and steelhead have steadily declined, reflecting changes in fisheries in response to declines in salmonid abundance. Lower Columbia River non-Indian commercial fisheries occur below Bonneville Dam in the mainstem or in select off-channel fishing areas. The Columbia River above Bonneville Dam to McNary Dam (Zone 6) was open to non-Indian commercial fishing until 1956. Commercial fishing for salmonids (gillnet and tangle net) occurs in the estuary and lower Columbia River, although it is heavily restricted in time and space. Washington and Oregon establish season dates and gear restrictions for mainstem commercial fisheries according to the Columbia River Compact.

Most commercial fishermen in the Columbia River also fish for other species, aside from salmonids, and hold permits in other states (e.g., 30 percent had fishing permits in Alaska). In 2004, there were 576 gillnet fishery permits in Washington (258) and Oregon (318), which, after accounting for permittee double permit holders and other factors, was 481 vessels (TRG 2014). In 2012, $3.1 million of salmon was harvested in the lower Columbia River non-Indian commercial fisheries by identifiable vessels (TRG 2014). In 2012, there were 244 vessels uniquely identified with the deliveries in the Lower Columbia River. Of these 244 vessels, the top 44 vessels by revenue harvested 50 percent of the total ex-vessel revenue in the gillnet fishery. The average active vessel gillnet revenue was $13,853, and the average top 10 vessel's gillnet revenue was $50,361 (TRG 2014).

3.3.4 Public Resources

Several comments from the public scoping period raised concerns over public health and other resources being impacted due to dispersal of DCCOs from managing such a large colony. This section addresses public health and human safety (as it relates to possible exposure to concentrations of DCCO guano), transportation facilities (i.e., DCCOs roosting or nesting on bridges, docks, airports, etc.), and dams and hatcheries (where DCCOs congregate and predate upon juvenile salmonids). The Corps worked with USDA-WS (the federal agency authorized by Congress to respond to wildlife conflicts) to provide an overview of DCCO-specific damage reports in the states of Oregon and Washington. When USDA-WS receives a damage report, they may investigate it to verify damage has occurred and assess the economic impact of the damage. In Washington, during a 5-year period from 2008-2013, reports of damage were highest at transportation facilities (airports, bridges, ferries, docks, and dams) and hatcheries. In Oregon, the Salem airport made the only report of damage to USDA-WS.

Public Health and Human Safety

Waterbird excrement can contain coliform bacteria, streptococcus bacteria, Salmonella, toxic chemicals, and nutrients, and can affect water quality and denude vegetation (USFWS 2003). USDA–WS commonly receives requests for assistance with bird damage caused by the accumulation of avian feces (guano). Guano contains corrosive acids and is laden with bacteria, either of which may endanger human health or impact buildings, bridges, and other structures (e.g., excessive fecal matter on handrails, stairs and walkways, ventilation intakes, etc.).

The disease most often associated with DCCOs is Newcastle disease, which is chiefly a disease of the central nervous system and is caused by infection with a type of avian paramyxovirus (Kuiken 1999). In 1997, Newcastle disease was diagnosed in juvenile DCCOs from breeding colonies in the Columbia River Estuary and Great Salt Lake, Utah by the National Wildlife Health Center. DCCO fledglings from East Sand Island have since been diagnosed with the disease in multiple years (i.e., 2003, 2005, 2007, 2009, 2013; BRNW unpublished data; see Roby et al. annual reports). While DCCOs on East Sand Island have tested positive for Newcastle Disease, they have tested negative for the highly virulent or velogenic form of the virus ("Exotic Newcastle Disease") that can severely impact commercial poultry operations (Roby et al. 2014). Evidence suggests that Newcastle disease is not an important cause of mortality in other wild bird species that nest in close association with DCCOs (Kuiken 1999).

Disease transmission may occur when people come in contact with contaminated areas or diseased birds. However, the people at greatest risk are those who come into direct contact with bird feces or are exposed to feces-contaminated dust in ventilation systems (USDA-WS 2011a). Symptoms in humans can include mild conjunctivitis and influenza-like symptoms (USGS 2010). Protective measures were taken (e.g., use of gloves, full coverage clothing, respirators, goggles, etc.) by research personnel on East Sand Island to avoid the potential for disease transmission. While there are concerns regarding the impacts of elevated contaminant levels and disease associated with concentrations of breeding or roosting DCCOs, direct disease transmission between DCCO and humans or adverse health effects to public health associated with DCCOs is unlikely to occur, even for research personnel in direct contact with DCCOs on East Sand Island.

Transportation Facilities

DCCOs can damage structures with fecal contamination. Corrosion damage to metal structures and painted finishes, including those on automobiles and boats, can occur because of uric acid from bird droppings. Accumulated bird droppings can reduce the functional life of some building roofs by 50 percent (Weber 1979). Damage of structures is more likely when high densities of DCCOs use these sites.

Given past dissuasion experiments, it is expected the Astoria-Megler Bridge will be a likely destination for DCCOs seeking new habitat (Figure 3-17). Several thousand DCCOs were observed roosting on the Astoria-Megler Bridge during the 2013 breeding season (D. Winterboure personal communication; Roby et al. 2014), marking a large increase in the numbers of DCCOs previously observed using the bridge. DCCO nesting on the Astoria-Megler Bridge has also increased. DCCOs were first observed nesting on the bridge in 2004, when six nests were counted. In 2013, 231 nests were counted (Roby et al. 2014). The colony is centered on the northern end of the northern truss of the bridge. The height of the bridge and the amount of boat traffic in the navigation channel make it an extremely difficult location to haze. Water cannons were the only successful method of hazing, but were discontinued due to corrosion concerns over use of saltwater on the steel structure.

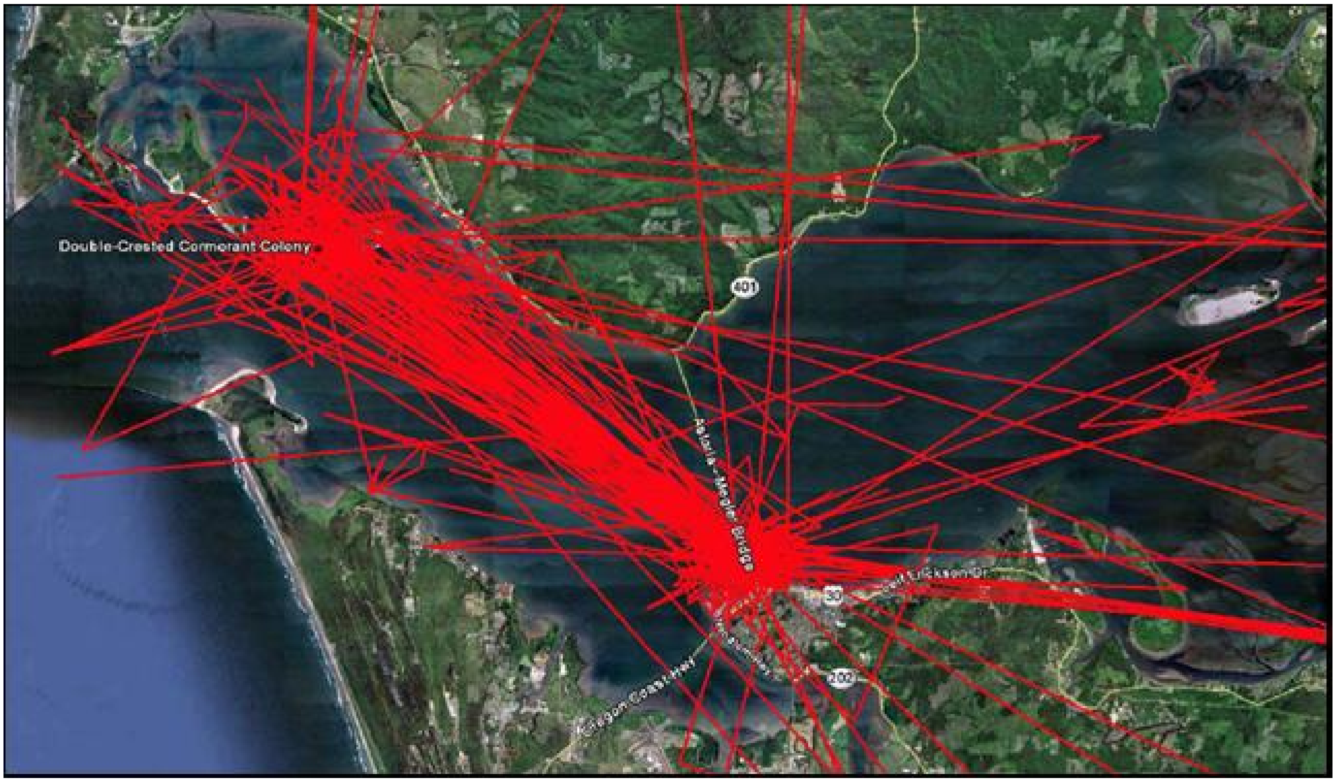


FIGURE 3-17. Movement of satellite-tagged DCCOs as a result of dissuasion experiments during the week of April 18, 2013. The majority of tagged DCCOs visited the Astoria-Megler Bridge.

Dams and Hatcheries

Dams and hatcheries are places of concern for depredation of fish by DCCOs. Juvenile salmonids become more susceptible to predation as they pass through the dams, which concentrate their numbers. The currents at outfalls can cause juvenile salmonids to become temporarily disoriented and remain near the surface, where they are more vulnerable to predation. USDA-WS works cooperatively with agencies and tribes to manage DCCOs and reduce predation damage at dams and hatcheries in Washington and Oregon. From 2008 to 2013, the majority of visits from Wildlife Services to investigate potential DCCO damage were at the dams (Ice Harbor, Little Goose, Lower Monumental, McNary, Priest Rapids, Rock Island and Wanapum), with 1,861 person-day visits over the 5-year period, and to the Cowlitz Hatchery, with 766 person-day visits (K. Christensen, personal communication).

3.3.5 Historic Properties

The affected environment for historic properties is referred to as the area of potential effect. This terminology comes from Section 106 of the National Historic Preservation Act. For the purposes of this EIS and proposed alternatives, that area is defined as the entire island, in order to address the placement of temporary dissuasion materials and construction of bird blinds, platforms, etc., for field personnel, as well as the proposed excavation for terrain modification. Ground disturbing activities from the proposed terrain modification method described in the alternatives (i.e., excavation of sand and lowering of rock armored shoreline to inundate the DCCO use area) could potentially affect historic properties in that area. This section then provides a historic context for Sand Island and describes in general terms the cultural resources and historic properties found on East Sand Island.

Historic Context of Sand Island

Historically, East Sand Island did not exist in its present configuration and was a part of the larger Sand Island, which in the early 1900s was adjacent to Fort Canby in Baker Bay. Dynamic forces, such as shifting sand bars (shoals), rolling breakers, severe storms and winds, and a strong current at the entrance where the Columbia River dissipates into the Pacific Ocean, create an environment that, prior to jetty construction and stabilization efforts, allowed for considerable changes and movement of Sand Island at the mouth of the Columbia River. Historical maps and surveys indicate that Sand Island moved nearly a mile to the west between 1840 and 1915 (McArthur 1915). In 1942, the *Oregonian* referred to Sand Island, stating: "A low elongated goose shaped sand bar in the mouth of the Columbia River is tagged the 'problem child' of the Columbia. In the course of time it changed its shape, cut itself in two, changed the course of ship channels, caused shipwrecks and became an enemy of navigation." It was not until the late 1930s when stabilization efforts on the recently breached Sand Island created the current configuration of East Sand Island.

Navigation

The Columbia River is one of the most treacherous areas in the world for navigation and is known as the "graveyard of the Pacific," due to the numerous shipwrecks, many of which are scattered on the bottom of the river. The *Isabella*, a Hudson's Bay supply ship that sunk in 1830, is off the northern shore of East Sand Island in approximately 48 feet of water, and is on the National Register of Historic Places. The *Great Republic,* one of the largest passenger liners on the Pacific Coast, ran aground offshore of Sand Island in 1879. This shipwreck site can be seen approximately 1 mile west of East Sand Island at some low tides. Historically, a north and south channel were used for navigation, but the north ship channel was abandoned in 1882, due to shoals forming between the Sand Islands and the mainland. Fishermen were blamed for the shoaling-in of the North Channel from the many piles and fish traps that slowed the water and allowed sand and silt to fill the channel (Darby 2014). To stabilize the navigation channel, a jetty system was constructed to keep the channel open with more predictability. The Sand Island pile dike system was a late element and part of the engineered navigation improvement system for the mouth of the Columbia River between 1880 and 1942. Periodic repairs, modifications, and construction took place along deteriorating and damaged portions of the islands' jetty and pile dike system throughout the twentieth century, with the last documented maintenance reportedly having taken place in the mid-1960s.

Military

In the late 1800s through World War II, the mouth of the Columbia was a critical strategic location militarily for harbor defenses and was protected by three military forts. Sand Island was set apart for military purposes (military reserve) by an Executive Order signed by Abraham Lincoln, dated August 29, 1863. Lieutenant Colonel H.R. Casey, stationed at Fort Canby in 1902, reported that "troops stationed at Fort Canby used Sand Island during Artillery practice as a location for fixed targets for practice with the 8" converteds and 15" smoothbores" (USACE 1992; HTRW Initial Assessment). Improvements to the Harbor Defense System in 1944 included installation of a system of anti-submarine mines in the river and a mine communication system on the recently stabilized East Sand Island. Three small concrete pillboxes, called "mine cable huts," were built, which were used in the mining operations of the mouth of the river. These mine cable huts are still present on the island, although two are half submerged on the southern shoreline.

Fishing

Baker Bay (also called "Bakers Bay") was historically the most important fishery on the lower Columbia, and rights to the fishing grounds were highly contested, especially on Sand Island. Conflicts occurred between gillnetters and trap fishermen, because fish traps blocked the nets. "Enormous hauls are sometimes made by these huge nets. At Sand Island where the first seining grounds inside the river are located, more than 20 tons of salmon have been caught in a single haul by one seine, and as high as 84 tons of salmon have been taken in a day" (*Oregonian* January 1, 1922). In 1935, soldiers were placed on Sand Island during the summer fishing season to prevent fishermen from occupying the island, closing the island permanently to fishing, due to ongoing fighting between various groups of fishermen.

Breach of Sand Island and Stabilization of East Sand Island

By the early 1930s, the south shoreline of Sand Island was eroding by increased current action, in part caused by the new river dynamics associated with jetty construction. In 1931, a small breech occurred on Sand Island, separating the island, and the general area of East Sand Island began taking shape. The Army had begun constructing a pile dike system on Sand Island, but could not prevent further erosion. The gap that separated Sand Island and East Sand Island became permanent by 1946, though there were efforts to repair it as late as 1952.

Historic Properties on East Sand Island

Four historic properties associated with military use and jetty or pile dike construction have been identified and recorded on East Sand Island (Figure 3-18)**.** One site associated with military use consists of three antisubmarine mine cable huts used for communications during World War II. These huts are small "bomb-proof" pillbox concrete buildings, constructed in 1942. A second site associated with military use of East Sand Island is the ruins of an observation tower used as part of the World War II-era Harbor Defense System. A historic, multiple-feature site associated with the efforts to stabilize

East Sand Island includes the rock armored (basalt) shoreline and pile dikes or jetty system, extending from the southern shore remains of the work areas, as well as equipment used in that construction effort. Remains on the island associated with this work include the basalt rubble mounds and wood pilings that once supported a train trestle, as well as track that transported rock used to armor the shore and construct the pile dikes. A related historic site located in the easternmost portion of the DCCO use area includes remains of a steam engine watering area (where a water tank for the steam engine once stood) and disposal area (bone yard) for discarded construction equipment. Several wheel sets from the rail cars and other artifacts are present in this location.

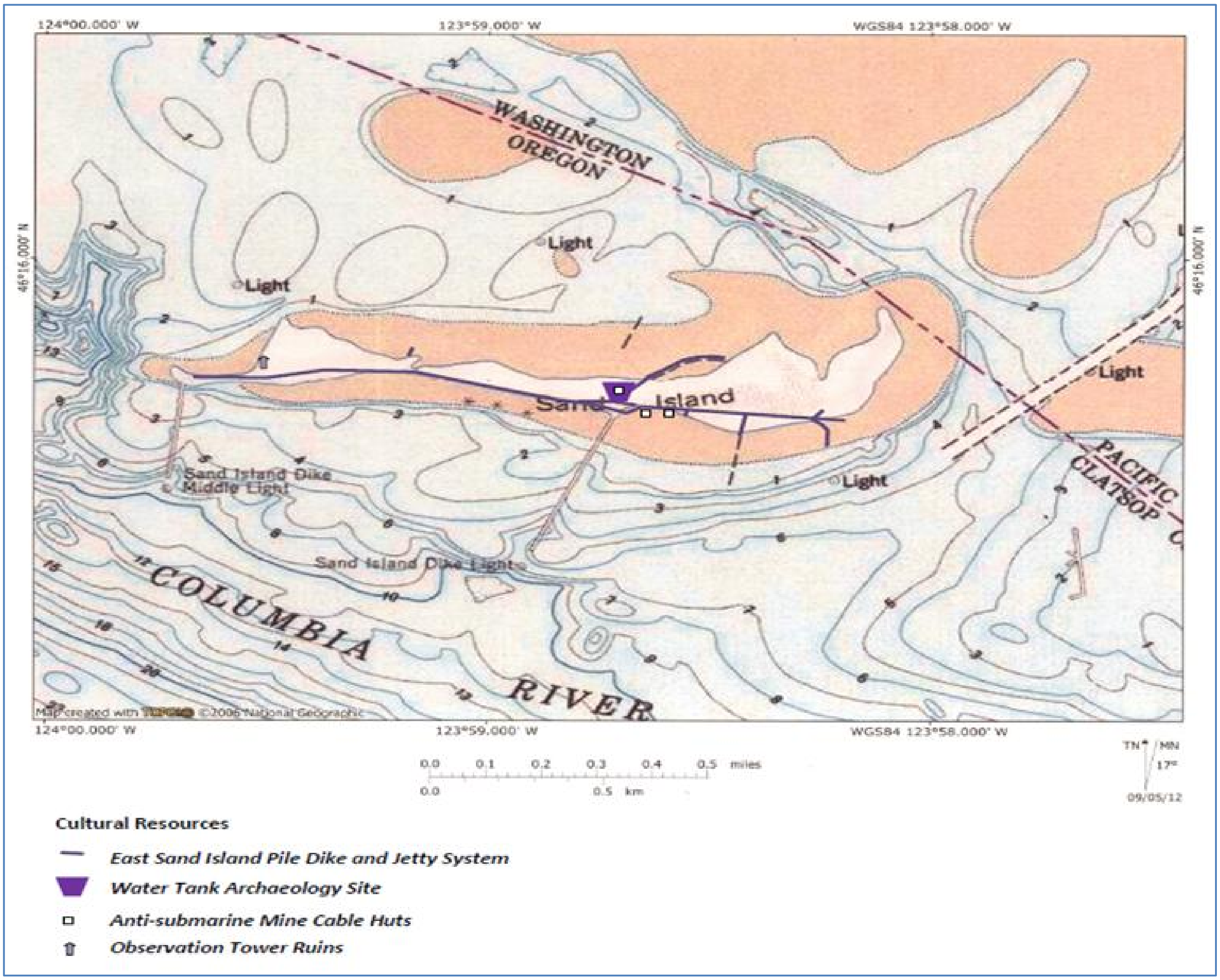


FIGURE 3-18. Historic properties recorded on East Sand Island.

Chapter 4 Environmental Consequences

4.1 Introduction

This section discusses the environmental consequences (effects) that may occur from implementing the various alternatives. Effects may be direct (an effect that is caused by an action and occurs at the same time and place) or indirect (an effect that is caused by an action but is later in time or farther removed in distance, but still reasonably foreseeable). The analysis of effects considers the context, duration, intensity, and type of effect. Generally speaking, effects could be beneficial and improve resources or conditions, or adverse and deplete or negatively alter resources or conditions. When effects are similar between alternatives, this is noted with a short statement (e.g., same as Alternative B).

Section 4.2 considers the effects to the biological environment, focusing most attention on the direct effects from proposed alternatives to DCCOs on East Sand Island, the western population of DCCOs, other birds that commonly use East Sand Island (i.e., Brandt's cormorants, California brown pelicans, Caspian terns, and gulls), and ESA-listed Columbia River juvenile salmon and steelhead. This section also includes discussions of other species that could be affected by DCCO dispersal and hazing. Those effects may be more indirect, occurring as a result of management actions on East Sand Island, but realized later in time or further removed from the site of the management action. For example, DCCOs may disperse to nearby Columbia River Estuary islands or relocate under redistribution alternatives to active or historic colonies along coastal Oregon and Washington where ESA-listed fish may be consumed. Section 4.3 considers the effects to the socio-economic environment, focusing attention on potential benefits to fisheries if DCCO predation rates decrease in the Columbia River Estuary. This section also considers effects to public resources from potential increases of DCCOs in new areas. Finally, this section addresses potential impacts to historic properties on East Sand Island under the different alternatives.

Section 4.4 considers cumulative effects in the context of other past, present or reasonably foreseeable future actions that, when combined with the proposed alternatives, may be cumulatively impacting the resources described in Chapter 3. Section 4.5 documents relevant climate change policies, identifies climate impacts likely to be relevant to East Sand Island and DCCO predation, and assesses potential inundation and land cover change under sea level rise scenarios. Section 4.6 considers other important factors for disclosure, such as unavoidable adverse environmental effects, energy requirements, and irreversible or irretrievable commitment of resources. This section also provides for disclosure of uncertainty in analyses and compensatory mortality in relation to the alternatives and disclosure of the human dimension of wildlife management given the context of the EIS. Section 4.7 provides a summary table of environmental consequences associated with the proposed alternatives.

4.2 Biological Environment

4.2.1 Effects to Vegetation and Soils on East Sand Island

Alternative A

Under the no action alternative, no management efforts would occur to reduce the DCCO colony and the presence of DCCOs would likely continue to prevent establishment of vegetation in the space the colony continues to occupy on East Sand Island. Several trees on the central portion of the island have been used for roost sites and may be used by DCCOs for nesting if no management occurs to prevent expansion of the colony to other areas. Field personnel have noted the excrement of DCCO guano is toxic to the species of plants upon which DCCO nest on East Sand Island, and former nesting sites of DCCO on the island, where there was previously vegetation, are now bare of all vegetation and no longer used for nesting (D. Lyons personal communication). Once vegetation was killed off, DCCOs typically moved to new areas with vegetation. Given the known impacts that DCCOs have on vegetation (Lemmon et al. 1994; Weseloh and Ewins 1994) and what has been observed on East Sand Island, it is likely that the diversity of tree and herbaceous plant species would be reduced if no management action is taken to reduce the DCCO colony or limit their expansion on the island. The large colony would continue to attract other colonial waterbirds, and accumulation of guano on the island would likely increase as more birds are attracted to the island.

It is unknown what effect the DCCO colony may have had or may currently be having on East Sand Island's soil nutrient status. DCCO guano can contribute to higher levels of soil nitrogen, phosphorus, carbon, potassium, and calcium (Ishida 1996; Hobara et al. 2001; Cuthbert et al. 2002; Ligeza and Smal 2003; Wait et al. 2005; Breuning-Madsen et al. 2010; Mizota 2009; Rush et al. 2011). However, nutrient accumulation is likely less pronounced (or less persistent) in high-rainfall environments with sandy-textured soils, such as East Sand Island. Hogg and Morton (1983) found that, in the Great Lakes region, most nutrient levels, salts, and pH had returned to near normal within one season of abandonment of gull nests. Because sandy soils have a low water-holding capacity and high infiltration rate, rainwater mobilizes deposited guano and rapidly leaches it through the soil profile. In addition, sandy-textured soils that are low in organic matter have a low cation exchange capacity, so nutrients in solution are not retained on soil particle surfaces. Most nutrients and contaminants deposited in seabird guano likely have a short residence time in the soil profile before being flushed through and into the river system.

Alternative B

Phase I – Alternative B proposes to use non-lethal methods to reduce the DCCO colony to approximately 5,600 pairs, which may result in the transition of vegetation to later seral stages of vegetational succession of plant communities on East Sand Island. As noted, sandy soils in high rainfall environments could flush out nutrient loads associate with guano within a few years. As the habitat is managed to constrict nesting to approximately 2 acres in the first year of management and to 1 acre or less thereafter, it is likely that passive restoration of soils and vegetation on East Sand Island, outside of the designated nesting area, would occur over a short period of time. Methods to exclude DCCOs would likely exclude other waterbirds from nesting and denuding vegetation; thus, restoration potential of plant communities where nesting and use is excluded is expected to be high.

Phase II – Modifying the terrain would exclude approximately 17 acres of nesting habitat on the western portion of the island and create intertidal mudflat or tidal marsh. Given the current state of vegetation on the western portion, creation of tidal mudflats and open marsh is expected to have direct and indirect short- and long-term benefits for habitat and vegetation complexity on the island. Direct impacts to soils and vegetation from construction activities associated with terrain modification would be low, as there is little complexity in soil horizon and vegetation communities in the area to be inundated. Impacts to soils and vegetation in the area where the remaining DCCOs would nest would be similar to what has been observed in the past, and this area would likely need to be constantly managed to ensure DCCOs do not expand in numbers on the island. Long-term strategies would be employed to minimize the effect of field personnel impacting vegetation or unintentionally spreading invasive species on the island through transport of equipment and materials.

There are no wetlands on the western portion of the island and none would be affected by the proposed excavation of approximately 300,000 cubic yards of sand within the DCCO use area. Direct impacts to wetlands could occur during disposal of this excavated sand on the eastern portion of the island. Additionally, disposal of sand in areas below high tide line (e.g., along the shoreline) would constitute a fill to waters of the U.S. Placement of approximately 30,000 cubic yards of rock armor on the northern shoreline below high tide would constitute a fill to jurisdictional waters. Disposal locations would be selected to avoid and minimize impacts to delineated wetlands and other waters of the U.S. where feasible. If, through final design of and selection of disposal sites, impacts to wetlands are determined unavoidable and there is no practicable alternative to placing disposal sites in delineated wetlands, appropriate mitigation measures would be developed to offset the impacts using on-island creation sites where possible. All efforts to avoid and minimize impacts to wetlands would be made through final design. Should disposal sites be located on the eastern portion of the island, it is possible that two delineated tidal estuarine wetlands, approximately 0.6 acre could be permanently filled. Potential mitigation for this impact could be enhancing other tidal estuarine wetlands present on the island or using a mitigation bank (see Appendix B for additional evaluation under Section 404 Clean Water Act).

Changes to inundation patterns, as proposed by the terrain modification, were modeled using the area-time inundation index model (ATIIM, Section 4.5.4). The expected inundation of the island at four water surface elevations is presented in Figure 4-1 to illustrate the range of inundation in the modified terrain condition. The lowest water surface elevation shown, 1.2 m (NAVD88) is equivalent to the current lower boundary of marsh elevation at reference sites in Baker Bay (Borde et al. 2011). The highest water surface elevation shown, 3.0 m, was the maximum water surface elevation reached for the modeled period, March to October 2009 (see Section 4.5.4). The most notable change from the inundation pattern seen in the existing condition is that, with the modified terrain, much of the western side of the island is inundated at water surface elevations greater than 2.2 m.

FIGURE 4-1. Water inundation outputs from the ATIIM for the terrain modification, representing four surface elevations: 1.2, 1.7, 2.2 and 3.0 m (NAVD88).

Alternative C *(Preferred Alternative/Management Plan)*

Effects to vegetation and soils under this alternative would be the same as Alternative B in Phase I and Phase II.

Alternative D
Effects to vegetation and soils under this alternative would be the same as Alternative B in Phase I. In Phase II, all DCCOs would be prevented from nesting on the island and long-term beneficial impacts from passive restoration and potentially active restoration on the island would likely improve diversity of vegetation communities, assuming no other seabirds replace the DCCO colony.

4.2.2 Effects to Double-crested Cormorants

Alternative A
Under this alternative no actions would be taken to reduce the rate of predation on juvenile salmonids from DCCOs nesting on East Sand Island or to reduce the DCCO colony size. As a result, the DCCO colony on East Sand Island would likely remain concentrated on the western portion of the island, and average abundance would presumably remain similar to approximately 13,000 breeding pairs in the near term, but may increase in the future. During 2004 to 2013, the size of the DCCO colony on East Sand Island averaged approximately 13,000 breeding pairs, but 2013 was the greatest size ever recorded (i.e., 15,000 breeding pairs, see Section 1.1.1). DCCO nesting success on East Sand Island would likely remain similar to the average during 1997 to 2013 (i.e., 1.83 fledglings produced per breeding pair, see Figure 3-11). The potential for DCCOs to increase in their abundance within the Columbia River Estuary and the affected environment would likely be unchanged. The East Sand Island colony would likely continue to comprise approximately 40 percent (13,000/31,200) of the western population of breeding DCCOs. Abundance of the western population of DCCOs is expected to remain similar to current levels in the near term (31,200 breeding pairs) and continue along past growth trends. The large DCCO colony would likely continue to attract other DCCOs and other colonial waterbirds to East Sand Island and the Columbia River Estuary. With more than 40 percent of the western population of DCCOs at one colony, disease outbreak or other natural mortality events at East Sand Island would result in a greater adverse effect to the western population of DCCOs than if the population were more evenly distributed.

Alternative B
Under this alternative, the Corps would implement non-lethal methods (i.e., hazing, temporary habitat modification) to reduce the DCCO colony on East Sand Island from the current colony size of approximately 13,000 breeding pairs to approximately 5,380 to 5,939 breeding pairs during Phase I, a 56 percent reduction. Limited egg take (up to 750 DCCO eggs in total; 500 on East Sand Island; 250 in other locations in the Columbia River Estuary) would also occur to facilitate successful implementation of non-lethal techniques. In Phase II, non-lethal methods (i.e., terrain modification, supplemented with temporary habitat modification and hazing, as necessary) supported with limited egg take would be used to ensure that Phase I abundance is not exceeded. Because this alternative proposes to utilize primarily non-lethal methods, abundance of the western population of DCCOs is expected to remain similar to current levels in the near term (31,200 breeding pairs). Future growth of the western

population of DCCOs would be less certain, but could likely be decreased compared to past growth rates. Within the western population of DCCOs, there could likely be a decrease in productivity until DCCOs dispersed from East Sand Island find new breeding sites and successfully produce fledglings at rates comparable to those on East Sand Island. Additionally, constraining abundance and future growth of the DCCO colony at East Sand Island could likely reduce overall growth of the western population of DCCOs, as most documented growth over the past decades has occurred at this colony (see Figure 4-2). However, if DCCOs successfully relocate and breed at other established or new colonies, growth of the western population of DCCOs in the future could likely be similar to current levels.

<u>Phase I - Effects to DCCOs on East Sand Island —</u> The DCCO colony on East Sand Island would be reduced to the target colony size of 5,380 to 5,939 breeding pairs and would comprise a smaller proportion of the western population of DCCOs than currently. The targeted colony size is approximately between the 1997 (5,023 breeding pairs) and 1998 (6,285 breeding pairs) observed abundance for the East Sand Island colony (Roby et al. 2014, see Section 1.1.1). Based on past research on East Sand Island, use of human hazers and privacy fencing was effective at dissuading DCCOs from nesting on certain areas of the island without precluding a viable DCCO breeding colony or having overall negative effects to DCCOs in the designated nesting area (BRNW 2013a, Roby et al. 2014). This would be the primary method used. Other non-lethal management techniques (see Chapter 2, section 1.2) could be implemented under the adaptive management process described in Alternative C (see Table 2.6). DCCOs flushing from the designated nesting area when eggs or chicks are present could decrease nesting success because of increased exposure and potential for predation (i.e., typically gulls that predated eggs and chicks immediately after a disturbance event; Kury and Gochfield 1975; Carney and Sydeman 1999; BRNW 2013a). However, overall direct or indirect adverse effects to DCCOs within the designated nesting area from actions taken under Alternative B are expected to be negligible and similar to effects during past research efforts. Productivity within the designated nesting area would likely remain similar to the average during 1997 to 2013 (i.e., 1.83 fledglings produced per breeding pair, see Figure 3-11).

To ensure that Alternative B can be implemented effectively, a minimal amount of egg take could occur (i.e., up to 750 DCCO eggs in total; up to 500 eggs on East Sand Island and 250 in other locations in the Columbia River Estuary in coordination with avian predation reduction efforts of the Corps' Channels and Harbors Program). Take of 500 eggs on East Sand Island represents approximately 1.0 percent of potential eggs from the East Sand Island colony in a given year (i.e., assuming 10-year average colony size (12,917 breeding pairs/nests) and 3.85 eggs per nest; [500/(12,917 * 3.85)]). Take of 250 eggs in other areas of the Columbia River Estuary represents approximately 0.5 percent of potential eggs from the East Sand Island colony in a given year (250/(12,917 * 3.85)). In total, take of 750 eggs represents approximately 1.5 percent of potential eggs from the East Sand Island colony in a given year (750/(12,917 * 3.85)).

Effects to DCCOs from non-lethal management have been well described (Parkhurst et al. 1987; Wires et al. 2001; USFWS 2003; Sullivan et al. 2006; Pacific Flyway Council 2012; Russell et al. 2012; BRNW 2013a). DCCOs attempting to nest outside of the designated nesting area would be actively hazed to preclude them from nesting. Direct adverse effects from hazing and disturbance include: 1) precluding DCCOs from nesting and using presumably optimally chosen areas on East Sand Island and 2) reducing individual fitness from the increased energetic demands from being flushed. DCCOs often depart nesting areas during a disturbance event (Ellison and Cleary 1978; Carney and Sydeman 1999; BRNW 2013a, Roby et al. 2014). Fidelity to a nest or a nesting area is typically greater later in the nesting cycle or breeding season, commensurate with individual investment toward producing and rearing offspring (Kury and Gochfield 1975; Ellison and Cleary 1978). Hazing in the dissuasion area on East Sand Island would be implemented frequently and repeatedly during the nest initiation period and likely extend greater than 11 weeks and into late chick or early fledgling stage of the breeding season.

Constricting the nesting area and hazing would result in approximately 7,250 DCCO breeding pairs being displaced from East Sand Island. DCCOs dispersed from East Sand Island could: 1) breed at other existing DCCO colonies; 2) breed at new locations; or 3) forego breeding until a suitable nesting habitat is found. It is unknown whether individual breeding success, survival, or DCCO-related management activities would be higher or lower in new breeding areas compared to East Sand Island.

Indirect adverse effects from reducing available nesting habitat on East Sand Island could likely include: 1) higher DCCO and other bird nesting concentrations on the west end, and 2) higher DCCO use and nesting attempts outside the designated nesting area and on the east side of the island. Displaced DCCOs and other birds (i.e., Brandt's cormorants, gulls) would likely attempt to nest within the designated nesting area, resulting in greater nesting density and concentration than observed on East Sand Island in the past. The DCCO colony would likely become more uniformly distributed within the designated nesting area at an approximate nesting density of 1.28 nests per square meter (the maximum nesting density observed during 2005–2013; BRNW unpublished data; see Figures 1-5 and 4-6) or greater. An increase in nest density and concentration could affect individual nesting success and overall productivity because of the potential adverse effects of increased nest-site competition. Concentration of the DCCO colony within a smaller area would likely increase the proportion of individuals affected during natural disturbance events (i.e., bald eagle, mammalian disturbance). Based on past dissuasion research results, magnitude and direction of effects from higher nesting density and concentration are uncertain. When nesting habitat was restricted during 2011 and 2012 (see Figures 1-5 and 4-6 for a visual of the colony restriction), nesting success was much lower than prior years and approximately 30 percent lower than the average during 1997 to 2013 of 1.83 fledglings produced per breeding pair (see Figure 3-11). Increased levels of bald eagle predation were suspected of causing the decline. In 2012, as many as 19 bald eagles were observed at one time on the west end of East Sand Island preying upon DCCOs and DCCO eggs and chicks (Roby et al. 2013). However, during 2013, the year of greatest habitat restriction and highest nesting concentration and bald eagles present in comparable numbers to prior levels, nesting success was 2.36 fledglings produced per breeding pair, the third highest for the period of record (1997–2013) and approximately 30 percent greater than the long-term average. In 1997 (i.e., when the colony was similar to the management target size), nesting success was slightly lower but comparable to the long-term average. These data show increased nesting density and concentration does not directly correlate to productivity rates, and large-scale factors aside from conditions on East Sand Island, such as ocean conditions and prey availability, likely affect nesting success to a large degree (Roby et al. 2014). Additionally, higher nesting density and concentration could potentially increase the risk for transmission of Newcastle's disease. However, during dissuasion research, this risk factor was present and did not appear to jeopardize the viability of the colony or suggest that further restriction of the colony would do so.

The likelihood of complete loss or abandonment of the DCCO colony on East Sand Island during Phase I from management activities under Alternative B is low. Although extensive hazing outside the designated nesting area and management activities on island would occur during much of the breeding season, the designated nesting area would remain rather undisturbed and would provide adequate nesting habitat. The remaining colony on East Sand Island would still be the largest within the western population of DCCOs.

Effects to DCCOs off East Sand Island — DCCOs that are unable to nest on East Sand Island would likely prospect for new breeding, roosting, and foraging sites within the Columbia River Estuary area before emigrating to other areas of the affected environment. DCCO abundance at prior use sites, such as the Astoria-Megler Bridge or Rice Island, and new sites within the Columbia River Estuary would likely increase. Alternative B (and common to all action alternatives) includes hazing in the Columbia River Estuary to ensure that displaced DCCOs from East Sand Island are re-located outside the estuary to achieve the reduction in juvenile salmonid predation rates specified in the 2014 FCRPS Biological Opinion (NOAA 2014). Boat- and land-based human hazing supported with limited egg take (250 eggs, see above) would be the primary techniques used to limit DCCO breeding, roosting, and foraging in the Columbia River Estuary, but other non-lethal management techniques (see Chapter 2, section 2.1.2) could be implemented under an adaptive management process (see Chapter 2.1.4). DCCOs hazed in the Columbia River Estuary would be exposed to direct and indirect adverse effects of disturbance as previously described for DCCOs on East Sand Island. Adverse effects from disturbance in foraging areas include decreased individual fitness (Grémillet et al. 1995). Overall DCCO occurrence in the Columbia River Estuary would likely be initially higher than current levels, but would be expected to decrease to current levels or lower after repeated years of active hazing. Completely deterring all DCCO from using the Columbia River Estuary seems unlikely due to the size of the scope of the area involved, logistical constraints, limited accessibility to many areas, and results of prior large-scale dissuasion research (see King 1996, Mott et al. 1998, Tobin et al. 2002). However, DCCO breeding, roosting, and foraging in the Columbia River Estuary would likely be reduced to some degree compared to no hazing effort. Avian hazing efforts that occur under the Corps' Dredge and Harbors Program have been successful in precluding DCCOs and other waterbirds from establishing nesting colonies on many of the Corp's dredge material islands over the past decades (see Roby et al. annual reports). Additionally, based on past research, hazing efforts would also likely preclude DCCO foraging and roosting from particular areas of the Columbia River Estuary (see Parkhurst et al. 1987, Wires et al. 2001, Dorr et al. 2010, Russell et al. 2012). The level of disturbance necessary before a DCCO would emigrate from the Columbia River Estuary is unknown and would likely be influenced by individual variability and temporal environmental conditions.

DCCOs within the affected environment, outside of the Columbia River Estuary, could be indirectly affected by DCCOs that disperse to those areas. Within the affected environment, the sub-regions most likely to experience DCCO abundance increases outside of the Columbia River Estuary would be the Washington Coast and the Salish Sea. The effect of DCCOs immigrating to new areas on other DCCOs already present within those areas is unknown, and would most likely be site-specific. Potential adverse effects of increased DCCOs on existing colonies include intra-specific nesting and foraging competition, and an increase in the potential for disease transmission. Potential beneficial effects include increased colony size that could result in excluding inter-specific nest site competition and buffering against disturbance events and predation.

Phase II - Effects to DCCOs on East Sand Island — DCCOs are highly philopatric and adults have high breeding site fidelity (Wires et al. 2001). Since the target colony size would be achieved non-lethally through dispersal in Phase I, future immigration to the colony and repeated nesting attempts by displaced DCCOs would likely be high. DCCOs that are deterred from nesting on East Sand Island in a given year or hatched on East Sand Island would likely continue to visit or prospect to breed at East Sand Island and within the Columbia River Estuary in later years, to some degree. Terrain modification supplemented with non-lethal management on East Sand Island in Phase II would be implemented to ensure the target size is not exceeded and DCCO juvenile salmonid predation rates remain at reduced levels, but the extent to which this can be achieved is unknown. Direct and indirect adverse effects to DCCOs from non-lethal management would be the same as described in Phase I. These effects would likely decrease through time as terrain modification changes are completed. No adverse direct effects are expected from construction activities from the terrain modification, as construction activities would occur during the in-water work period and outside the breeding season (November 15 to February 15).

Effects to DCCOs off East Sand Island — Effects would be the same type as described for Phase I. The duration of effects is unknown and largely dependent upon how long DCCOs remain committed to the estuary, but would likely decrease through time as displaced DCCOs establish nesting colonies elsewhere.

Alternative C *(Preferred Alternative/Management Plan)*

Under this alternative, the Corps would implement primarily lethal methods (i.e., on- and off-colony shooting) during Phase I to reduce the DCCO colony on East Sand Island to between 5,380 and 5,939 breeding pairs (ca. 1997 to 1998 colony abundance). Non-lethal methods supported with limited direct egg take up to 750 eggs (i.e., 500 on East Sand Island and 250 for other locations in the Columbia River Estuary), as described in Alternative B, would be used concurrently with lethal methods. An adaptive approach would be used to achieve the East Sand Island DCCO target colony size. The Corps would initially undertake a 4-year lethal strategy to achieve the target size (by the end of 2018 if implementation began in 2015; see Section 2.2.3 for description of field methods and adaptive approach and Appendix E.2 for modeling and effects of take levels). Through adaptive management, the lethal strategy could be adjusted to a 3- or 2-year strategy by increasing take levels after the first year of lethal management. Take levels and year strategies could change based upon deviation of observed abundance from predicted abundance, DCCO colony and population response to lethal take, and knowledge gained during implementation concerning what levels of annual take can be effectively achieved. Under a 4-year lethal strategy, 20.3 percent of the DCCO colony would be culled each year (mid-point between the two carrying capacity scenarios modeled in Appendix E-2), resulting in a total take of 15,956 DCCOs in all years (5,230, 4,270, 3,533, and 2,923 DCCOs in years 1 to 4, respectively). Take levels in subsequent years could be adjusted to a 3-year strategy (i.e., 28.8 percent of colony taken in years 2 and 3; 15,790 DCCOs total; 6,071 and 4,489 in years 2 and 3) or 2-year strategy (i.e., 48.0 percent of colony taken in year 2; 15,386 DCCOs total; 10,156 in year 2; see Table 2-5). Proposed individual take levels would include and account for the associated amount of indirect nest loss that could occur from taking the proposed number of individuals. Overall, under the 4-year or adjusted 3- and 2- year lethal strategies, total take levels would be similar and abundance of the western population of DCCOs after implementation of Phase I would be approximately the same.

During Phase I, abundance of the western population of DCCOs would likely be reduced to approximately 46,500 breeding individuals (by the end of 2018 under the 4-year strategy if implementation began in 2015; by the end of 2017 for the 3-year strategy; by the end of 2016 for the 2-year strategy; see Appendix E-2). This abundance is approximately 5,000 breeding individuals greater than observed abundance in ca. 1990 for the western population of DCCOs (41,660 breeding individuals; Tyson et al. 1997). The East Sand Island DCCO colony would comprise a smaller proportion of the western population of DCCOs than currently observed. Under Phase II, management would shift to a non-lethal focus (same as Alternative B) to ensure that the target size is not exceeded and DCCO juvenile salmonid predation rates remain at reduced levels.

Phase I - Effects to DCCOs on East Sand Island — Lethal management techniques for DCCOs and effects to DCCOs resulting from lethal management have been well described (Bedard et al. 1997; Wires et al. 2001; USFWS 2003; Ontario Parks 2008; Pacific Flyway Council 2012; Russell et al. 2012; Guillaumet et al. 2014). In general, lethal techniques result in the loss of individuals or eggs, chicks, or fledglings; a reduction in abundance, for a given area or to a population or colony, depends upon the scale of lethal management and whether the level of loss is greater than the effects of immigration, recruitment, and other density-dependent mechanisms (USFWS 2003). The primary lethal technique proposed is take of individuals. Other lethal management techniques (see Chapter 2, section 2.1.2) are not proposed but could be implemented under an adaptive management process (see Chapter 2, section 2.1.4). The direct adverse effect of take of individuals under the 4-year lethal strategy (see summary above) is loss of 20.3 percent of DCCOs from the colony annually, including the number of associated nests that are indirectly lost.

The primary method of lethal take off-island would be with shotguns from boats or stationary positions. Shotguns could be used on or near East Sand Island, in areas and at distances sufficient to allow DCCOs to nest within the designated nesting area. Direct adverse effects to individuals in close proximity to those taken include injury and disturbance from visual stimuli (i.e., shooter, loss of other individuals) and noise, if silencers and suppressors are not used. Retrieval rates on culled individuals off-island would likely not be 100 percent, as DCCOs may be lost in the water. Techniques described in Chapter 2 would be used to ensure retrieval rates that are as high as possible, given field conditions. Because of the distance of actions, potential direct adverse effects to DCCOs within the designated nesting area are assumed to be negligible with these techniques.

The primary method of lethal take on-island would be small caliber rifles. Direct adverse effects from take with rifles include disturbance to individuals in close proximity to those taken and disturbance to the immediate area when carcasses are retrieved. Injury to proximal DCCOs would be negligible with rifles and presumably all culled individuals would be retrieved. Because of the effectiveness of privacy fencing and the use of sub-sonic shot, silencers, and night-shooting (see Chapter 2.1.2), potential direct adverse effects to DCCOs within other areas where take does not occur are assumed to be minimal.

Take of individuals would be a more effective technique than egg take in reducing the colony by the end of the 2018 timeframe of the 2014 FCRPS Biological Opinion. Lethal take of breeding adults has a greater impact on reducing abundance than removing eggs, chicks, or fledglings, as DCCOs are a long-lived species with high adult survival relative to other life stages and breed throughout their adult lives (Ludwig and Summer 1995; Hatch and Weseloh 1999; Blackwell et al. 2002; also see Appendix E). Ludwig and Summer (1995) estimated that culling adults had a 3- to 6-fold greater effect on the population than culling fledglings, chicks, or eggs. DCCOs typically breed in their third year (Hatch and Weseloh 1999), and, with egg take, there would be a multiple year delay before decreased recruitment affects the colony or population size (Bedard et al. 1997; Guillaumet et al. 2014). Direct take of active nests, eggs, chicks, or fledglings is not proposed as a primary lethal technique, but this loss would occur indirectly resulting from the take of breeding adults that may be actively nesting when culled. Since both parents equally care for offspring, if one individual of a breeding pair is culled, the remaining individual of a breeding pair cannot sufficiently protect offspring and provide them food (Bedard et al. 1997; Strickland et al. 2011). The most extreme active nest loss scenario was modeled and included within the proposed take percentages (1 active nest per 1 individual, which represents each individual being from a separate breeding pair, see Appendix E-2). Actual nest loss is expected to be lower, as some individual take would occur before nesting or would not be associated with a nest and some of the individuals taken would be pairs. Individuals of a breeding pair that lose their partner would have no productivity in subsequent years until becoming paired again (Strickland et al. 2011). Both Bedard et al. (1997) and Strickland et al. (2011) documented male bias when culling, approximately 2:1 males per female. Males generally are more territorial and stay longer when disturbed and typically are the first to return after a disturbance (Bedard et al. 1997, Strickland et al. 2011). Culling a higher proportion of males than females could skew sex ratios within the pool of available DCCOs attempting to breed at East Sand Island, resulting in faster reduction in the colony size than anticipated, as was documented by Bedard et al. (1997) and Strickland et al. (2011), and decreased productivity until unpaired individuals pair again.

To avoid impacts to nesting DCCOs, lethal take would occur as early in the year as possible. If lethal take on-island extends into the nesting season, based on prior research and the lethal techniques proposed in Alternative C, the majority of take on-island would likely occur within a 2 to 3 week time period, if DCCOs are committed to East Sand Island. Greater direct and indirect adverse effects to DCCOs would occur if: 1) lethal take extends into the breeding season or the longer lethal take extends into the breeding season; 2) the more frequent lethal take sessions occur; and 3) a larger area on-island and off-island is included for lethal take. Exposure to multiple shooting events or repeated and persistent disturbance, particularly early in the breeding season, could increase dispersal. Effects described would be greater during the primary time period when the majority of lethal take occurs. The exact level of dispersal from Alternative C is unknown, albeit the expected magnitude of dispersal would likely be minimal compared to Alternative B. Direct adverse effects from non-lethal management outside the designated nesting area would be the same as described in Alternative B; effects are expected to be less under Alternative C compared to Alternative B because fewer individuals are expected to be displaced outside the designated nesting area (i.e., more DCCO would be directly taken and not displaced and hazed).

Proposed annual take levels on East Sand Island are comparable to take levels of other culling programs in Canada and the United States that effectively reduced DCCO abundance to acceptable levels for mitigating impacts to resources in particular areas. In total abundance, reducing the DCCO colony on East Sand Island from the 10-year abundance average (12,917 breeding pairs) to the target range (5,380 and 5,939 breeding pairs) is an approximate 56 percent reduction in colony size. During 2004–2006 at Presqu'ile Provincial Park, DCCO nesting abundance was reduced by approximately 6,000 breeding pairs (i.e., 67 percent reduction), and annual culling and nest take rates were 20 to 51 percent and 5 to 36 percent, respectively (Ontario Parks 2008). Within Thunder Bay, Lake Huron, 33 percent culling rates were used to reduce colony abundance (USFWS 2003). At Young Island, Vermont, a DCCO colony was reduced from approximately 1,500 breeding pairs in 2004 to zero breeding pairs in 2008, when culling 20 percent of adults and oiling 100 percent of nests annually (Duerr et al. 2007; Strickland et al. 2011). Within the St. Lawrence River Estuary, DCCO abundance was reduced from 17,361 breeding pairs in 1989 to 9,561 breeding pairs in 1993 (i.e., 45 percent reduction) with approximate annual culling rates of 5.7 to 9.4 percent and nesting oiling rates of 31 to 51 percent (Bedard et al. 1997). At the Les Cheneaux Islands, Michigan, total DCCO nesting pairs were reduced approximately 74 percent from 5,487 in 2003 to 1,436 in 2007 with approximate annual culling rates of 9.7 to 47.2 percent and nesting oiling rates of 41.9 to 77.7 percent (Dorr et al. 2010).

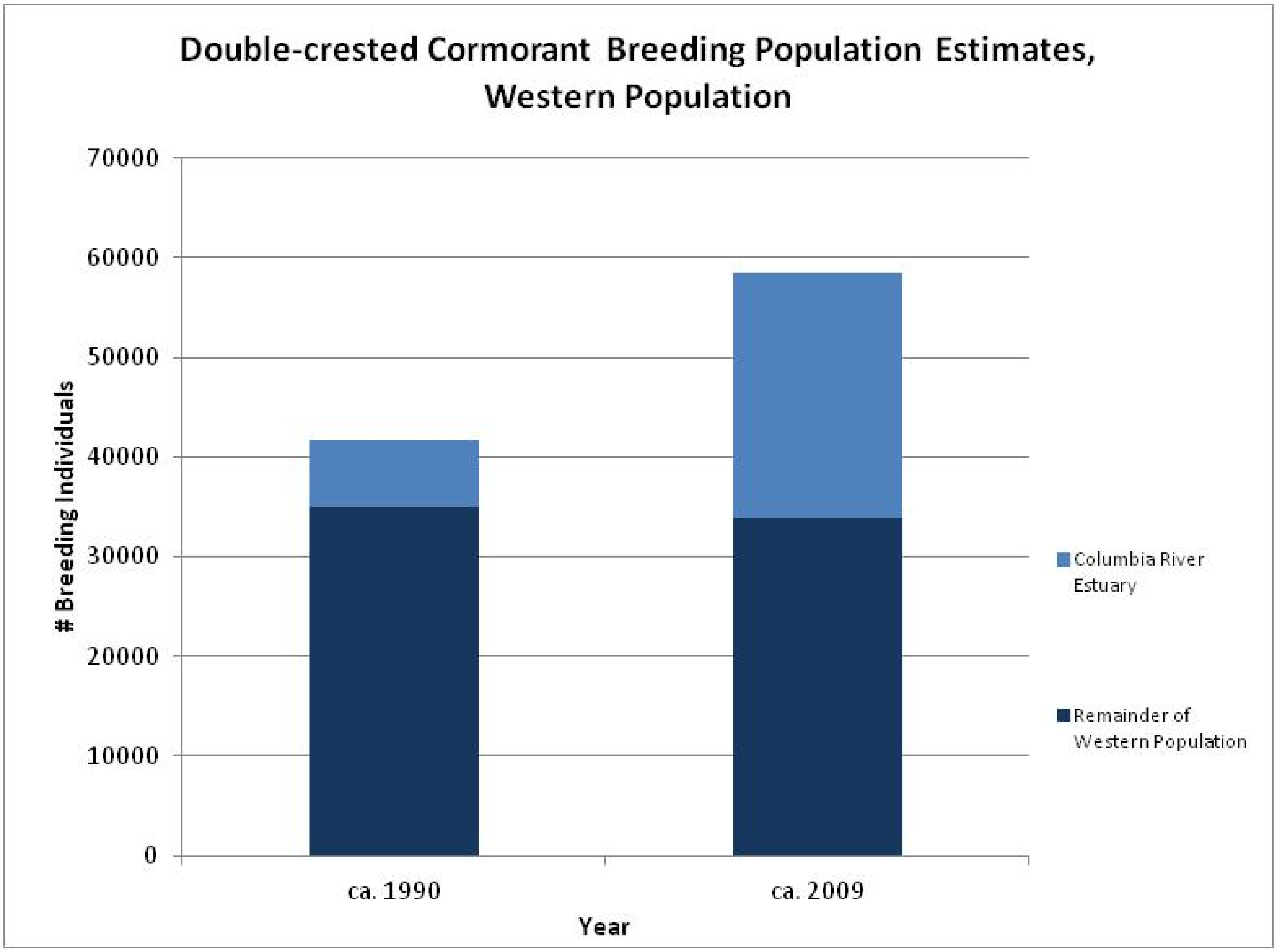
The risk of colony abandonment or the size of the DCCO colony on East Sand Island dropping or staying below the target size, based on the take levels proposed, is low. Measures to minimize disturbance would be put in place to ensure a viable nesting colony within the designated nesting area and other large-scale culling programs in Canada and the United States at well-established and large colonies have not resulted in colony abandonment, even if the take levels were greater than the proposed take levels in the EIS (see Bedard et al. 2007; Ontario Parks 2008; USDA-WS 2009; Dorr et al. 2010). The designated nesting area would provide adequate nesting habitat for the target population size, and the remaining colony on East Sand Island would still be the largest within the western population of DCCOs. A large number of fledglings would likely be produced each year, and the colony would continue to attract DCCOs to the area. Additionally, conservative measures were used in the modeling approach for deriving take levels (see Appendix E-2), and take would occur within a well-monitored and adaptive management framework, with take and other management activities ceasing if annual peak colony size falls below the target size.

Effects to DCCOs off East Sand Island — Effects would be the same type as described in Phase I of Alternative B. Effects are expected to be less compared to Phase I of Alternative B because of less expected dispersal of DCCOs.

Effects to the Western Population of DCCOs — Based on modeled population trajectories of the western population of DCCOs, which include an additional take of 936 DCCOs within other areas of the western population (see Appendix E.2), the proposed take levels for the 4-year lethal strategy is expected to result in an abundance of 46,764 (41,540–51,988) breeding individuals after Phase I, or a 25 percent decline in the western population of DCCOs from its current abundance (62,400 breeding individuals; Adkins et al. in press). The adjusted 3-year lethal strategy is expected to result in a 25 percent decline and an abundance of 46,818 (41,418–52,218) breeding individuals. The adjusted 2-year lethal strategy is expected to result in a 26 percent decline and an abundance of 46,464 (40,970–51,957) breeding individuals. Under all year strategies, abundance after Phase I is expected to be approximately 5,000 breeding individuals greater than observed abundance in ca. 1990 for the western population of DCCOs (41,660 breeding individuals; Tyson et al. 1997).

Abundance of DCCOs in North America has been documented through several assessments and compilations of surveys and has fluctuated through time (see Carter et al. 1995, Tyson et al. 1997, Wires et al. 2001). DCCO populations declined during the 19th century, including the western population, due to egg-collecting, disturbance from seal-hunting operations, and other human disturbances (Hatch 1995). The Interior population has the most available data and mostly likely represents what had occurred throughout North America. The Interior population increased from the 1920s to the 1950s (Hatch 1995, Wires et al. 2001). Pesticides then started to have major impacts and the Interior population fell to low levels about 1970 and was recognized as a species of "Special Concern" in several states (Wires et al. 2001). Environmental contaminants were shown to have impacts in California as well through the 1960s and 1970s (Gress et al. 1973). Coordinated, regional survey data is not available prior to the 1990s for the western population of DCCOs; thus, an accurate depiction of historic abundance and trend is not available. Much of the current population growth observed across North America occurred between the late 1970s and early 1990s and was the result of reduced levels of environmental contaminants (particularly DDT, which was banned in 1972), protection of DCCO under the MBTA in 1972, and creation of additional breeding and foraging habitat (dredge material islands; Wires et al. 2001). Documented changes in distribution of the western population of DCCOs occurred in the 1980s and 1990s with growing breeding colony sizes along the Oregon Coast coinciding with declines in British Columbia and Washington (Carter et al. 1995). Since 1990, the growth of the western population of DCCOs has been primarily associated with the growth of the East Sand Island colony (Adkins and Roby 2010, Figure 4-2). Thus, it appears that the western population of DCCOs is sustainable at approximately ca. 1990 numbers. A sustainable population is defined for this analysis as a population that is able to maintain numbers above a level that would not result in a major decline or cause a species to be threatened or endangered.

Based on model simulations presented in Appendix E-2, the risk of jeopardizing the sustainability of the western population of DCCOs from the take levels proposed is low, as take levels proposed in Alternative C are expected to result in 5,000 breeding individuals greater than ca. 1990 abundance after Phase I under all year strategies. At this abundance, within the coastal states and provinces, which account for approximately 90 percent of the western population of DCCOs, DCCO abundance increased 71 percent (approximately 3 percent per year) during the last two decades, but nearly all of the growth of the western population of DCCOs was attributed to abundance increase at the East Sand Island colony (Adkins et. al in press, see Figure 4-2). With nesting habitat reduced and growth on East Sand Island limited, the western population of DCCOs could remain static after abundance is decreased to approximate ca. 1990 levels, since most growth since 1990 occurred at East Sand Island. However, mortality factors known to limit DCCO populations prior to the 1970s (i.e., environmental contaminants and hunting [DCCOs were protected under the MBTA in 1972]) have been reduced or eliminated, along with improved waterbird conservation, management, and habitats throughout the United States (see Section 4.4 describing history of colonial waterbird conservation planning). Although the particular colony where most of the observed growth of the western population of DCCOs would be limited, large-scale environmental, regulatory, and management changes that have occurred over the past decades could allow for growth of the western population of DCCOs to continue. DCCOs that nest on East Sand Island typically spend half of the year away from East Sand Island; thus, the increase in abundance at the East Sand Island colony most likely cannot be solely sourced to that location alone and likely reflects beneficial environmental changes that have occurred throughout the geographic area occupied by DCCOs that nest on East Sand Island. Risk is further reduced given that take on East Sand Island would occur within a well-monitored and adaptive management framework, an annual depredation permit application would need to be approved and issued prior to take, and standardized, periodic monitoring of the western population began in 2014 (Pacific Flyway Council 2012). Additionally, there are extensive examples throughout the United State and Europe of DCCO and Great cormorant (*P.* carbo) populations increasing concurrent with and after lethal management (USFWS 2003, 2009, 2014; Russell et al. 2012; Guillaumet et al. 2014). However, these populations are an order of magnitude larger than the western population of DCCOs, and there is more uncertainty in how the western population of DCCOs could respond to the proposed levels of culling.



*Estimate for western population of DCCOs ca. 1990 was from Tyson et al. 1997, Appendix 1 minus Alaska. Date ranges were 1975–1992. Western population estimate for ca. 2009 was from Adkins and Roby (2010). Data were from 2009, except for coastal California (2008) and many interior California sites (1999). Columbia River Estuary estimates for ca. 2009 were from Adkins and Roby (2010) and were from 2009; Columbia River Estuary estimate ca. 1990 were from Carter et al. (1995) as reported in Adkins and Roby (2010). Date ranges were 1990–1992.

FIGURE 4-2. Double-crested Cormorant breeding population estimates for the western population, ca. 1990 (Tyson et al. 1997) and ca. 2009 estimate (Adkins and Roby 2010); the Columbia River Estuary portion of the western population is highlighted (Adkins and Roby 2010).

Proposed take rates are similar or higher than take rates proposed and implemented nationally and among states for DCCO management. Proposed take levels would be for 4 to 2 years of lethal management, whereas national and state management, described below, were for annual, on-going take; thus, rates are not entirely comparable. Additionally, there have not been large-scale culling programs within the western population of DCCOs, compared to interior DCCO populations. As previously mentioned, uncertainty in how the western population of DCCOs would respond is greater than that of interior DCCO populations, and this should be given consideration when comparing culling programs from those regions. Population growth rates were higher in the interior population, compared to the western population of DCCOs (Wires et al. 2001; USFWS 2003; Adkins and Roby 2010), and East Sand Island is not within a connected matrix of other large breeding colonies within the affected environment, as is the case within the Great Lakes region. Annual take levels proposed on East Sand Island under the 4-year strategy, plus additional annual authorized take within the western population of 936 individuals, represents an approximate 8 to 10 percent individual and 6 to 10 percent nest loss of the western population of DCCOs. Under the adjusted 3-year strategy, take percentages would increase to 11 to 12 percent individual and 9 to 11 percent nest loss in years 2 and 3. Under the adjusted 2-year strategy, take percentages would increase to 20 percent individual and 18 percent nest loss in year 2 (see Appendix E-2).

Under the preferred alternative of the national DCCO EIS, the estimated expected total mortality to the continental population under both depredation orders was approximately 8 percent per year, and this level of take was expected to have minimal effects on the long-term conservation of DCCOs (USFWS 2003). Expected take rates of the actual populations within the 24 states included under the depredation order would be higher than the continental level (i.e., >8 percent per year). Actual take rates and population impacts under the depredation orders are difficult to estimate, as total population estimates are uncertain and take in Canada is not reported under the depredation orders. During 2004–2012, on average, 43,423 DCCOs were taken annually in the 24 states under the depredation orders (USFWS 2014). Take rates for Great Lakes populations are best known (including both U.S. and Canadian estimates). During 2009, the estimated annual percentage of the different Great Lake populations culled ranged from 0.04 to 8.9 percent (USFWS 2014). The estimated annual adult take and nest oiling rates under the PRDO for the Great Lakes DCCO population were 6 percent and 14 percent, respectively (USFWS 2009, 2014). These levels of take were estimated to decrease the Great Lakes DCCO population by 20 percent by 2014 but would not significantly reduce or threaten the long-term conservation of DCCO populations (USFWS 2009). In Michigan, maximum annual adult take levels were approximately 3 to 18 percent of the state population during 2005–2009 (USDA-WS 2011b). In Wisconsin, annual DCCO take levels of 18 percent of the summer population were selected in an environment assessment (USDA-WS 2009).

Phase II - Effects to DCCOs on East Sand Island — Indirect effects from terrain modification would be the same as Phase II of Alternative B. Direct adverse effects from non-lethal management supported with limited egg take to ensure the target colony size is not exceeded would be the same type of effects as described in Phase II of Alternative B; effects would likely be low in the short-term compared to Phase II of Alternative B but could become higher if growth potential of the colony increases through time. Lethal take could result in a diminution of density dependent regulatory mechanisms, which, over time, could result in higher in-situ recruitment (i.e., survival and productivity) at the colony or within the population or higher rates of immigration of other DCCOs to the colony compared to prior observed levels. Guillaumet et al. (2014) found density dependence to be the most important class of factors in explaining DCCO colony growth within the context of cumulative DCCO management; additionally, higher growth rates were observed at colonies where culling of breeding adults occurred at least 2 years previously, suggesting in-colony recruitment or immigration from nearby colonies increased when density dependent regulation was lessened. Terrain modification supplemented with non-lethal management on East Sand Island in Phase II would be implemented to ensure the target size is not exceeded and DCCO juvenile salmonid predation rates remain at reduced levels, but the extent to which this can be achieved is unknown.

Effects to DCCOs off East Sand Island — Effects would be the same type as described in Phase II of Alternative B; effects likely low in the short-term compared to Phase II of Alternative B but would become higher if growth potential of the colony increases through time.

Alternative D

Under this alternative, the Corps would implement lethal management during Phase I, the same as Alternative C, to reduce the DCCO colony on East Sand Island to 5,380 to 5,939 breeding pairs. After Phase I, the DCCO colony on East Sand Island would be reduced to approximate 1997 abundance; abundance of the western population of DCCOs is expected to be approximately 5,000 breeding individuals greater than observed abundance in ca. 1990 (41,660 breeding individuals; Tyson et al. 1997). In Phase II, the same terrain modification and non-lethal management supported with limited egg take as in Alternative B and C would be used to remove all DCCO nesting on East Sand Island and to disperse the remaining approximate 5,600 breeding pairs away from the Columbia River Estuary. This would result in a substantial effect to the distribution of the western population of double-crested cormorants and potentially similar or greater effects to those described in Phase I of Alternative B, where redistribution of the colony is proposed. Precluding all double-crested cormorant nesting on East Sand Island would likely have greater effects to the western population of double-crested cormorants compared to just redistributing a portion of the colony. Within the western population of DCCOs, there could likely be a decrease in productivity until DCCOs dispersed from East Sand Island find new breeding sites and successfully produce fledglings at rates comparable to those on East Sand Island. Excluding East Sand Island as a DCCO breeding colony could likely reduce subsequent growth of the western population of DCCOs. However, if DCCOs successfully relocate and breed at other established or new colonies, growth of the western population of DCCOs could likely be similar to current rates. Extensive hazing efforts, in addition to terrain modification, would likely be needed to remove all DCCOs from nesting on East Sand Island and to preclude re-establishment in subsequent years. Once the colony is removed and subsequent re-establishment is deterred for multiple years, effort to maintain zero DCCOs nesting on East Sand Island would likely be low thereafter, in the long-term, as there would be no large colony to continue to attract DCCOs to the area and produce offspring with philopatry to the area. Likelihood of deterring all DCCOs from nesting, roosting, and foraging from the entire Columbia River Estuary would be much less likely than deterring all DCCO nesting on East Sand Island. A long-term hazing effort, comparable or greater than that described in Phase I of Alternative B, would likely be needed to relocate all DCCOs from the Columbia River Estuary.

Phase I - Same as Alternative C.

Phase II - Effects to DCCOs on East Sand Island — Direct and indirect adverse effects from terrain modification and non-lethal techniques supported with limited egg take would be the same type as described in Phase II of Alternative B; effects would likely be high in the short-term to preclude all DCCO nesting and re-establishment but low or negligible thereafter in the long-term since few or no DCCOs would be present on East Sand Island.

Effects to DCCOs off East Sand Island — The expected amount of DCCO dispersal from East Sand Island (approximately 5,600 breeding pairs) would be similar to Phase I of Alternative B (approximately 7,250 breeding pairs). Effects would be the same type as described in Phase I of Alternative B; effects would likely initially be high, and then decrease once all DCCOs are redistributed outside the Columbia River Estuary.

4.2.3 Effects to Other Birds Common to East Sand Island

Effects to other birds on East Sand Island from management activities would be similar to those described for DCCOs and include: 1) direct effects from disturbance to proximal individuals when implementing non-lethal or lethal techniques; 2) restriction of habitat and hazing resulting in higher levels of nesting concentration, co-nesting with other species, or dispersal; and 3) loss of individuals or eggs from implementation of management actions, including misidentification during lethal take. Effects would be most pronounced to species that nest on East Sand Island during the duration of the year when DCCOs occur and management activities are underway, and to species that nest within the DCCO colony or nest on the west side of the island where the majority of management activities would occur.

With regard to temporal usage, other waterbird species that typically nest on East Sand Island (i.e., Caspian terns, Ring-billed gulls, Glaucous-winged/western gulls, and Brandt's cormorants) nest in close temporal overlap with DCCOs, with the minor exception that Brandt's cormorants arrive later and have later breeding than DCCOs by approximately 2 weeks (Table 4-1). California brown pelicans typically use East Sand Island for night roosting (2013 was the first documented instance of egg laying; n=3 nests) and peak use and attendance is later (typically August) compared to the other waterbird species nesting on the island (typically early June; Figure 4-3). California brown pelican abundance shows great inter-annual variation in total numbers, and diurnal use is strongly positively correlated with tide cycles (i.e., higher abundance observed during high tide; lower abundance during low tide, due to more prevalent foraging during low tides; Wright et al. 2007).

TABLE 4-1. Nesting Chronology and Attendance Patterns of Piscivorous Waterbirds on East Sand Island.

Species	Arrival		First egg		First chick		First fledgling		Peak attendance (adults) in 2013		Departure
	Range	2013	Range	2013	Range	2013	Range	2013	Count	Date	2013
Double-crested cormorant	3/27 - 4/11	4/11	4/21 - 5/5	4/27	5/21 - 6/2	5/27	7/5 - 7/22	7/12	14,916 (b)	6/8	October
Caspian tern	3/25 - 4/7	4/7	4/14 - 5/2	4/23	5/13 - 6/3	5/28	6/19 - 7/15	7/5	11,424 (c)	6/16	September
Brandt's cormorant	4/10 - 4/16	4/11	5/6 - 5/10	5/6	6/7 - 6/8	6/8	7/28	7/28	1,720 (c)	6/9	October
Glaucous-winged/western gull	<March	<March	no data		no data		no data		4,580 (d)	6/8	November
Ring-billed gull	March	March	no data		no data		no data		2,676 (d)	6/8	August
California brown pelican	3/16 - 4/28	4/22	7/15	7/15(a)	na	na	na	na	3,850 (e)	8/7	November

a) first year egg laying documented on ESI in 2013; typically use East Sand Island for night roost
b) peak number nests from aerial photo
c) peak ground count from blind
d) adults from aerial photo at peak nesting
e) peak island-wide ground count

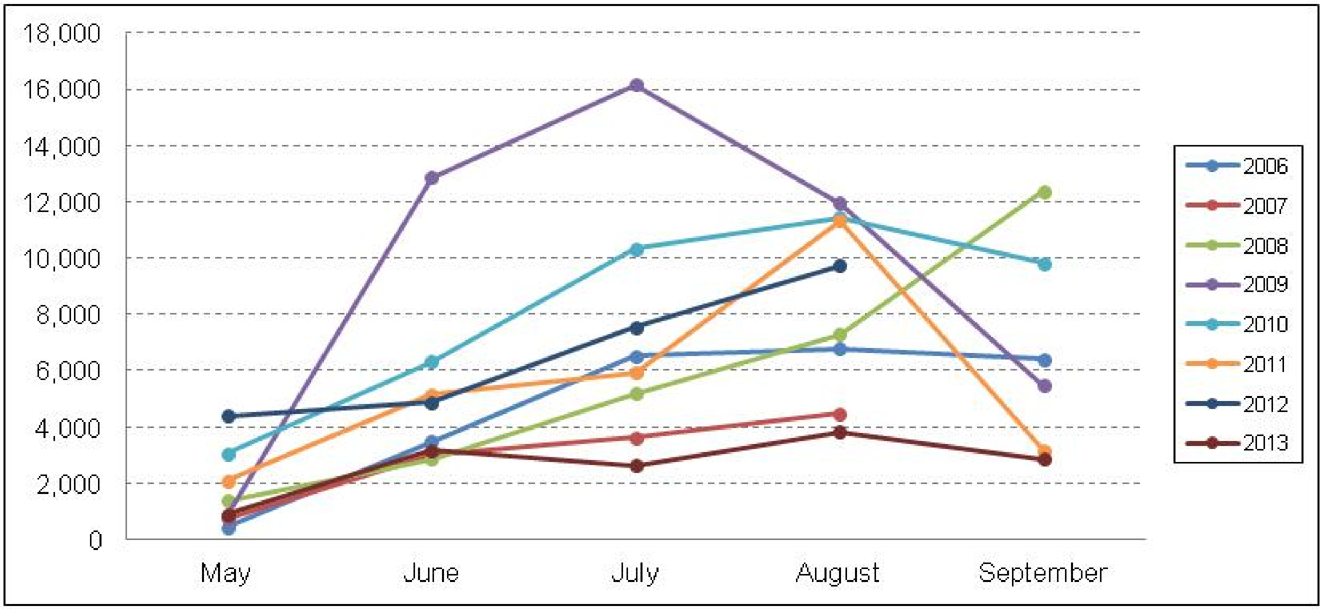


FIGURE 4-3. Monthly average number of brown pelicans roosting on East Sand Island during evening surveys conducted between 2006 and 2013.

With regard to spatial distribution of species that co-nest with DCCOs on East Sand Island, Caspian terns and Ring-billed gulls nest exclusively on the eastern portion of the island (Figure 4-4). Glaucous winged-western gulls nest throughout the island, including the western portion (Figure 4-5). Brandt's cormorants nest in closest association with DCCOs, nesting entirely within the boundaries of the DCCO colony (Figure 4-6).

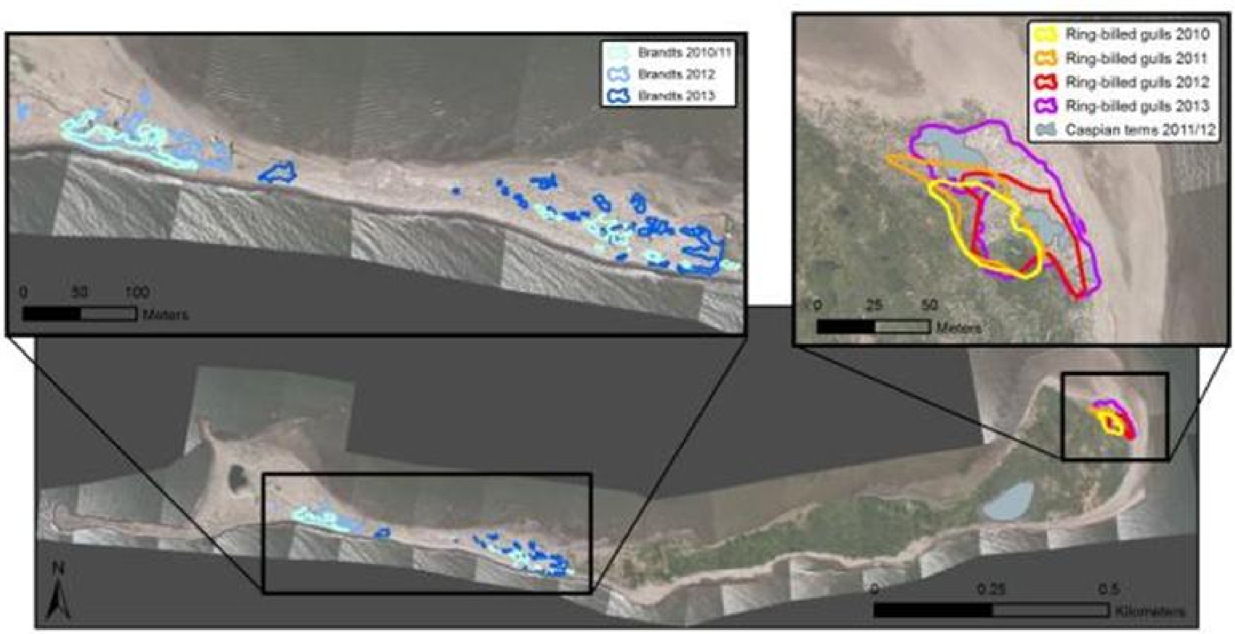


FIGURE 4-4. Spatial distribution of Brandt's cormorants (2010–2013), Ring-billed gulls (2010–2013), and Caspian terns (2011–2012) on East Sand Island.

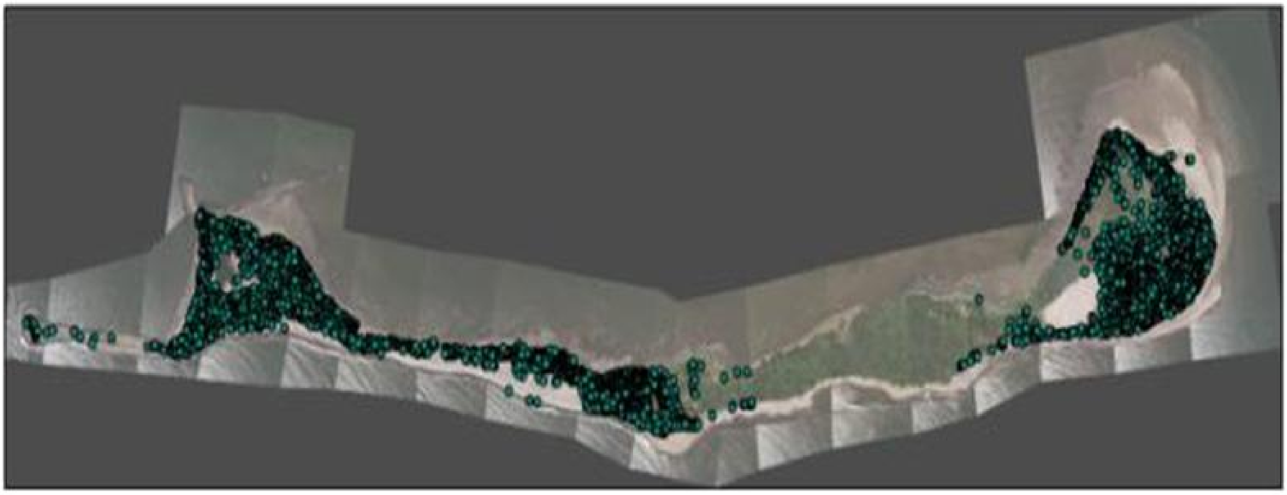


FIGURE 4-5. Spatial distribution of Glaucous-winged/western gull (2013) on East Sand Island.

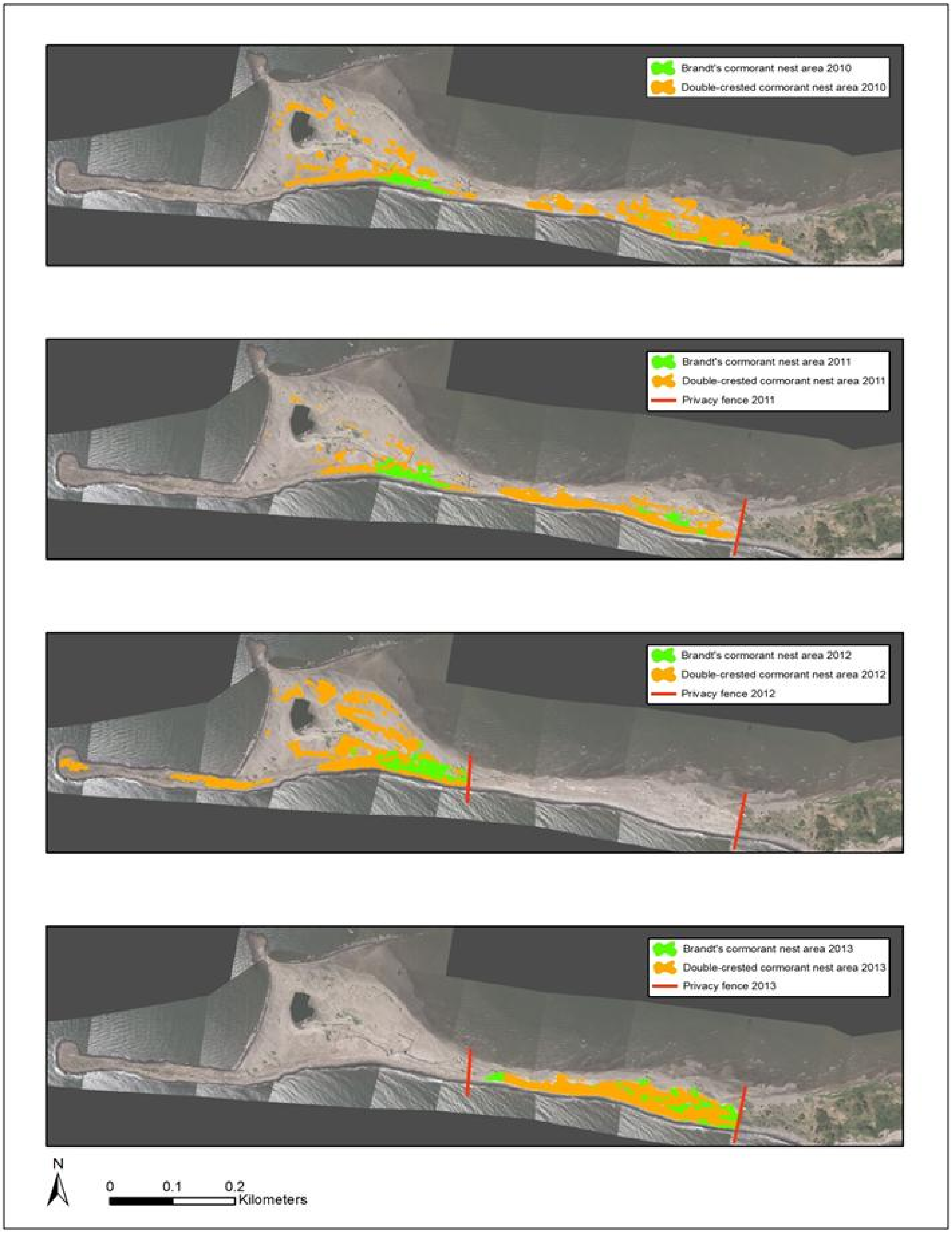


FIGURE 4-6. Spatial overlap of Brandt's cormorant and DCCO nesting (2010–2013) on East Sand Island.

Alternative A

No actions to manage DCCOs would occur under Alternative A and colony size and abundance of other co-nesting species on East Sand Island would presumably remain similar to current levels in the near-term, with the exception of Caspian terns who would continue to be managed under the 2005 EIS to achieve a target colony size of approximately 3,000 nesting pairs (USFWS 2005a). Human presence and resulting disturbance on the island, due to DCCO research and monitoring, would cease. Spatial distribution of species would likely remain similar to current distribution, with the exception that California brown pelican usage may be more temporally and spatially uniform in response to reduced management activity (Caspian tern and other management activities would still occur).

Alternative B

Phase I - Direct adverse effects from implementing Alternative B are expected to be higher than prior dissuasion research, as more habitat would be restricted and greater levels of hazing would be needed to disperse approximately more than 7,250 DCCO breeding pairs from East Sand Island. A high potential exists for DCCOs deterred from nesting in the designated nesting area to use the east side of the island; thus, high levels of hazing and disturbance are expected throughout and on the east side of the island to preclude DCCOs from nesting. Expansion of hazing to reduce DCCO colony would adversely affect other nesting species (i.e., gulls, terns, pelicans described in Chapter 3, section 3.3) in those areas or cause individuals to emigrate temporarily or permanently from East Sand Island. Non-lethal techniques could result in nest destruction, abandonment, or failure, and increased susceptibility of eggs and chicks to predation. These actions could result in loss of nests, eggs, or chicks of other nesting species on East Sand Island. Adaptive Management approaches described in Chapter 2 would be implemented to minimize take of non-target species. Quantifying this level of take is not possible, but levels would likely be comparable or higher than those that occurred during past dissuasion research and have similar effects to these populations. Management activities are expected to extend into July or later, which would overlap most of the nesting cycle for species that typically nest on East Sand Island and push into the peak time period of usage by California brown pelicans.

Effects to bald eagles and other raptor species are expected to be negligible. Bald eagles and other raptor species do not nest on East Sand Island, so actions could only impact foraging opportunity. Based on prior dissuasion research, management activities have had little impact on precluding bald eagles and raptors from foraging on-island. These species are opportunistic and generalist predators, and actions would not appreciably limit or change overall prey availability. For example, Watson et al. (1991) found that fish compose the majority of bald eagle diet in the Columbia River Estuary.

High disturbance to or potential loss of the Brandt's cormorant nesting colony on East Sand Island could occur, since they nest in close association with DCCOs. Establishment of a mono-species nesting colony outside of the designated nesting area would likely not be feasible, since DCCOs would likely be associated (thus there would be hazing in that area). Additionally, Brandt's cormorants typically arrive and initiate nesting a few weeks after DCCOs. If Brandt's cormorants are forced to nest within the designated nesting area, it is unknown how competitively Brandt's cormorants would fare in comparison to DCCOs, if nesting habitat is limited and DCCOs are already established within the designated nesting area. Since establishment of the colony in 2006, estimated size of the Brandt's cormorant colony decreased in comparison to the year prior for the first time in 2013, the year of greatest habitat restriction. Although this represents only one year, it could suggest some limiting of Brandt's cormorant abundance when DCCO habitat is restricted. Loss of the Brandt's cormorant colony on East Sand Island (i.e., approximately 3,200 breeding individuals or 4 percent of the regional population) and subsequent dispersal of individuals would likely have negligible effects on the regional population, which is estimated to be approximately 74,000 breeding individuals.

Non-lethal management would likely affect spatial distribution of California brown pelicans to a greater extent than during past research efforts, given expected expansion of hazing efforts, but likely would have little effect on limiting or reducing overall California brown pelican annual abundance. California brown pelicans typically use the intertidal zone and adjacent upland habitat, and tend to avoid roosting on broad mud flats or densely vegetated interior portions of East Sand Island (BRNW 2013b). In 2013, California brown pelican egg laying was documented for the first time on the eastern end of East Sand Island. Spatial distribution and primary use areas vary throughout the year, with the majority of usage typically occurring in areas that have least associated disturbance (i.e., both boating and on-island and both natural and human caused).

During 2010–2013, when DCCO habitat modification and dissuasion research was on-going and predominantly focused on the west end of the island, California brown pelicans were more abundant on the East Beach and South Beach during the early months of the field season (i.e., May and June), with other areas (i.e., West End and North Beach) becoming more populated in later months as the total numbers of roosting California brown pelicans increased island-wide (BRNW 2013b; Figure 4-7). During 2001 and 2002, Wright et al. (2007) also observed distributional changes in California brown pelican usage over the course of the year, largely in response to disturbance activities on the island. Wright et al. (2007) found that land-based human activity and, in particular, shotguns fired within 400 m of the roost had the greatest effect on California brown pelicans roosting on East Sand Island. During 2013, the year of greatest DCCO habitat restriction and hazing, California brown pelicans were observed roosting in and adjacent to the dissuasion area throughout the active hazing period (up to June 30, which is prior to the peak usage of California brown pelicans), with up to 3,500 individuals observed roosting in these areas at times. California brown pelicans were disturbed during nine hazing events, with a maximum of 500 individuals flushed during one event (Roby et al. 2014). Additionally, during 2010–2012, primary areas of active DCCO management were subject to variable and continuous use by California brown pelicans, despite ample alternative roosting habitat elsewhere on East Sand Island (BRNW 2013b).

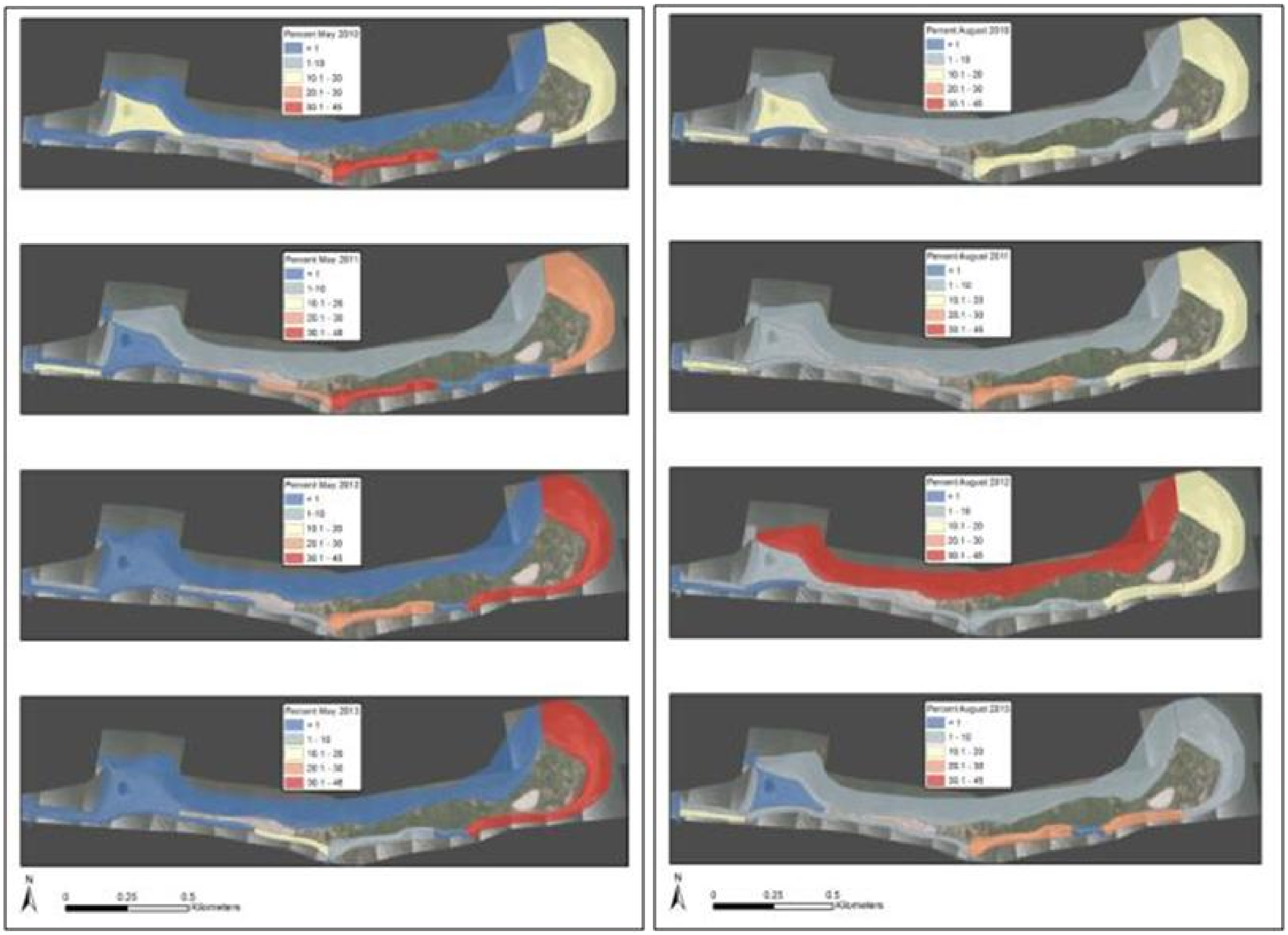


FIGURE 4-7. California brown pelican use on East Sand Island by sighting zone during May (left panel) and August (right panel) during 2010–2013.

Reduced DCCO abundance and DCCO use of the east side of the island and subsequent hazing could reduce Caspian tern and Ringed-billed gull abundance or nesting success. It is likely that DCCOs would attempt to seek out the most undisturbed areas on East Sand Island, if continuously hazed. DCCOs have not previously attempted to nest within the designated area prepared for Caspian terns, so likelihood of, and effects from, direct nest site competition are unknown. DCCO use of areas proximal to the Caspian tern and ring-billed gull colonies (i.e., close enough so that hazing would affect them too) could be high, if these areas are undisturbed compared to the rest of the island. Reduced DCCO abundance on East Sand Island could intensify disturbance and predation to Caspian terns and Ringed-billed gulls by bald eagles, Glaucous-winged/western gulls, and other predators, as these species would compose an overall higher proportion of the prey base on East Sand Island. Bald eagle disturbance and subsequent predation has been cited as a factor limiting nesting success of Caspian terns in recent years (Roby et al. 2014).

Of the nesting species on East Sand Island, impacts to Glaucous-winged/western gulls would likely be negligible. Glaucous-winged/western gulls nest throughout the island and would be less impacted by spatial use changes of DCCOs. Additionally, they appear to be rather resilient to levels of disturbance expected from hazing. During past dissuasion research, several thousand Glaucous-winged/western gulls nested and raised young within the DCCO dissuasion areas (Roby et al. 2014). Reduced DCCO abundance could reduce or shift prey base of Glaucous-winged/western gulls, but it is not known to what degree, or if, this would reduce their abundance.

Phase II - Under Alternative B, the need for continued non-lethal management (thus disturbance) on the remaining available habitat outside the designated nesting area would be high for both the short- and long-term in Phase II. For other species on East Sand Island, this could likely alter spatial distribution of use on-island, decrease abundance or nesting success, or promote emigration for both the short- and long-term in Phase II. No short-term adverse direct effects are expected from construction activities from modifying the terrain, because construction activities would occur during the in-water work period and outside the breeding season (November 15 to February 15).

Long-term adverse and beneficial effects of modifying the terrain are expected for other birds using the island. Inundation of the western portion would also preclude Brandt's cormorants from nesting and reduce, to a great extent, Glaucous-winged/western gulls nesting on the west end of the island. This would reduce available habitat overall for nesting species on East Sand Island and would increase nesting concentration and levels of co-nesting on the east side of the island. The vegetative cover on the east side may become denuded or deteriorated if DCCO nesting in that area becomes prevalent and consistent, thus, creating a habitat structure and type similar to that currently on the west end. This may increase potential available habitat on the east side for the other nesting species on East Sand Island, as all species nest in open habitat. Terrain modification would likely increase the available amount of intertidal habitat, which is used by California brown pelicans; thus, anticipated effects to California brown pelicans from terrain modification would be beneficial or negligible.

Alternative C *(Preferred Alternative/Management Plan)*

Phase I - Since DCCO abundance decrease would occur primarily from lethal take, not dispersal, less non-lethal management is expected under Phase I compared to Alternative B; thus, effects from non-lethal management would be similar to those described in Alternative B but less. Little to no direct disturbance from lethal take is expected to species on the east end of the island. The primary window for lethal take on-island (less than 2 to 3 weeks) would likely occur prior to or extend into only a portion of the breeding season. Potential for management-related adverse effects to species' later nesting stages (i.e., late egg laying, chick, fledgling) and impacts to California brown pelicans would be low, since the majority of management activities would occur prior to chick rearing and the arrival of the majority of California brown pelicans. During primary periods of lethal take, potential for more pronounced adverse effects could occur, resulting in deterring other species from using and nesting within areas where lethal take occurs, changing spatial distribution of use on the island, and likely short-term, but possibly long-term, emigration.

Brandt's cormorants are the non-target species with the highest potential for take due to close association with DCCOs and potential for misidentification. During 16 years of diet studies on Rice and East Sand Island, in which 2,351 total DCCOs were lethally taken with shotguns, take of 12 Brandt's cormorants occurred during 8 of those years (BRNW 2013a). This is a take rate of 0.5 percent. Given the magnitude of take and different methodologies, higher take rates could occur under Alternative C. Under the 4-year lethal strategy (15,956 DCCO taken in total; 5,230, 4,270, 3,533, and 2,923 DCCOs taken in years 1–4, respectively), and a 3 percent take rate of Brandt's cormorants, which was determined from input by cooperating agencies, up to 479 (15,956 x 0.03) Brandt's cormorants could be taken in total during years 1 to 4 under this scenario. Total take would be similar under the 3-year (15,790 DCCOs; 474 Brandt's cormorants) and 2-year (15,386 DCCOs; 462 Brandt's cormorants) strategies. The Brandt's cormorant colony on East Sand Island is approximately 3,200 breeding individuals, which is approximately 4 percent of the regional population for Washington, Oregon, and California (74,000 breeding individuals; see Table 3-2). There is a potential for take of up to approximately 0.2 percent of the regional population of the Brandt's cormorants per year under the 4-year strategy, or up to 5 percent of the East Sand Island colony per year. Take of 462 to 479 Brandt's cormorants would have direct adverse effects on individuals and associated breeding pairs and likely limit or reduce the size of the Brandt's cormorant colony on East Sand Island. However, this level of take would likely have negligible effects on the regional population (i.e., under the 4-year strategy, take of approximately 0.21 percent (157 individuals [5,230*0.03]/74,000 [regional population]), 0.17 percent (128/74,000), 0.14 percent (106/74,000), and 0.12 percent (88/74,000) of the regional population during years 1–4, respectively). If DCCO take levels increase in subsequent years under adaptive management, take levels could be as high as 0.3 percent (182 individuals [6,071*0.03]/74,000]) of the regional population and 6 percent (182/3200) of the colony on East Sand Island in year 2 under the adjusted 3-year lethal strategy or 0.4 percent (305 individuals [10,156*0.03]/74,000]) of the regional population and 10 percent (305/3200) of the colony on East Sand Island in year 2 under the adjusted 2-year lethal strategy. Expected take levels would likely be lower, given the BMPs and Adaptive Management approaches described in Chapter 2 to minimize take of non-target species. Additionally, if lethal take occurs early in the year, soon after arrival of DCCOs, expected rates would be lower, since Brandt's cormorant arrival and nesting cycles are a few weeks delayed compared to DCCOs.

Phase II - Effects to other birds on East Sand Island under Phase II would be the same type as described in Alternative B, but the need for high levels of non-lethal management on East Sand Island in Phase II in the short-term is expected to be low; need for non-lethal management would increase if the growth potential of the DCCO colony increases after lethal take commences.

Alternative D

Phase I - Same as Alternative C.

Phase II - Effects from terrain modification would be the same as described in Alternative B. Effects associated with concurrent non-lethal management supported with limited egg take would likely be high in the short-term to preclude all DCCO nesting and re-establishment but low or negligible thereafter in the long-term since few or no DCCOs would be present on East Sand Island. To prevent all DCCO nesting on East Sand Island, hazing would likely have to occur throughout the entire island during the entire breeding season; thus, adverse effects to other nesting bird species, including abundance reduction and potential for colony abandonment from management actions would be very high. Exclusion of only DCCOs, which have significant temporal overlap with other nesting species on island and can nest in close spatial association with those species, would likely be difficult without significantly affecting other co-nesting species. Exclusion of all DCCOs on East Sand Island could adversely affect Caspian terns and Ring-billed gulls by increasing and intensifying predation on these species. With regard to regional populations, dispersal of a large majority, or all, of a given nesting species from East Sand Island would likely have the greatest impact on Caspian terns, which have a high concentration of the regional abundance at East Sand Island (i.e., 60 percent) compared to the other species (2–16 percent; see Table 3-2). Conversely, exclusion of DCCOs could benefit other nesting bird species on the island, as more suitable nesting, roosting, or foraging opportunities may become available.

4.2.4 Effects to Other Birds

Species considered in Chapter 3, section 3.2.3 were those within the sub-regions of the affected environment, particularly the Columbia River Estuary, Washington Coast, and Salish Sea, that co-nest or overlap in habitat use with DCCOs, and are a conservation concern. Additionally, species in the Columbia River Estuary may be directly impacted by management actions, including hazing and take of non-target species. Islands identified as potential dispersal and hazing locations (i.e., Rice, Miller Sands Spit, Pillar Rock; see Table 2-3) and other islands in the Columbia River Estuary and locations along the Washington coast were recently designated critical habitat for the streaked horned lark (50 CFR 17.95(b)). In addition to effects from hazing DCCOs in the estuary, bird species within the affected environment may be affected by DCCO abundance increases, resulting from DCCO emigration from East Sand Island. However, predicting or quantifying these direct or indirect effects can be difficult or tenuous in open, complex systems, even with detailed study.

Alternative A

Abundance and distribution of other bird species considered in this section would presumably remain similar to current conditions in the near- and long-term. Direct or indirect adverse effects to other birds are expected to be similar to levels prior to habitat modification and hazing research, which likely increased dispersal levels.

Alternative B

Phase I - Approximately more than 7,250 DCCO breeding pairs would be dispersed from East Sand Island into the Columbia River Estuary and affected environment. Co-nesting species that use the same habitat and forage for the same prey species as DCCOs have the greatest potential to be affected via inter-specific competition. Adverse effects from DCCO abundance increases to new areas may include: 1) increased nesting and foraging competition; 2) increased dispersal, colony abandonment, or disruption in breeding; 3) increased disease transmission; and 4) destruction of nesting habitat for certain species through defoliation or denuding vegetation. Interactions concerning competition are complex, and DCCO abundance increases alone at a given location does not necessarily correlate to increased nesting or foraging competition. For example, sub-sites or habitat within a site could be used differentially by DCCOs and co-nesting species (e.g., cliffs [pelagic cormorants] vs. level areas [DCCOs]; see Siegel-Causey and Hunt 1981). Beneficial effects from DCCO abundance increase could include: 1) increased colony size buffering against predation and 2) denuding of vegetation, making areas more desirable to species that use open habitats. Actual effects to other birds would be commensurate with dispersal levels to new areas and subsequent site-specific interactions.

Adverse effects to herons and other obligate tree nesting species from destruction of trees by DCCO guano accumulation have been documented in the northeastern United States (USFWS 2003). This has not been documented in the affected environment; thus, no direct or indirect adverse effects are expected to herons, as there is little overlap between the species at existing breeding colonies within the sub-regions of the affected environment.

Potential for DCCO dispersal to and the need for DCCO hazing at islands designated critical habitat for streaked horned larks would be high. For example, Rice Island is an important streaked horn lark nesting area in the Columbia River Estuary and a former colony site for DCCOs. Streaked horned larks have the greatest potential to experience direct and indirect adverse effects under Alternative B due to expected DCCO dispersal in the estuary and subsequent hazing activities. Regional population size for the species is much smaller than other bird species considered (see Table 3-3). Due to the potential for adverse effects and potential for take that may result from hazing during the breeding season, an adaptive monitoring and hazing plan would be coordinated with the USFWS Endangered Species program. Hazing could be limited, if not restricted entirely, for some time periods and areas, on islands that are designated critical habitat for streaked horned larks.

Potential for DCCO dispersal to and need for DCCO hazing at Astoria-Megler Bridge, which could adversely affect the pelagic cormorant colony by disturbing nesting birds resulting in nest failure, and Miller Sands Spit, which could adversely affect the American White Pelican colony, would be high. Monitoring and hazing at these areas would likely need to occur over a long period of time. Non-lethal techniques could result in nest destruction, abandonment, or failure, and increased susceptibility of eggs and chicks to predation. These actions could result in take of nests, eggs, or chicks of other nesting species. Adaptive Management approaches described in Chapter 2 would be implemented to minimize take of non-target species. Adverse effects to the regional population of American White Pelicans and pelagic cormorants from management actions would likely be negligible since the colonies in the Columbia River Estuary compose a small proportion of these species' regional populations; approximately 0.2 percent and 0.5 percent, respectively (see Chapter 3, section 3.2.4).

Phase II - Need of continued DCCO non-lethal management and hazing would be high. Effects to other birds in the affected environment outside of the Columbia River Estuary would be commensurate with dispersal levels to new areas and subsequent site-specific interactions, and would likely be less than Phase I. Long-term adverse effects to species that overlap with DCCOs in the estuary are expected from hazing, as described under Phase I. No direct or indirect adverse effects are expected from the proposed terrain modification to any other birds that do not commonly use East Sand Island. Indirect benefits may result from an increase in intertidal mudflats that could support foraging and roosting opportunities for shorebirds.

Alternative C *(Preferred Alternative/Management Plan)*

Phase I - DCCO dispersal from East Sand Island is assumed to be minimal under this alternative compared to more than 7,250 breeding pairs considered under non-lethal management. Effects to other birds would be commensurate with dispersal levels to new areas and subsequent site-specific interactions, but is assumed to be low. Streaked horned larks are the primary species of concern in the Columbia River Estuary. Under Alternative C, additional hazing, beyond what is currently done for the Corps' Channels and Harbors program, is not expected; thus, adverse effects from hazing would be comparable to past levels. Any hazing activities on islands with, or expected to have streaked horned larks, would occur under the Corps' Channels and Harbors Program in coordination the USFWS Endangered Species program. If abundance reduction of the DCCO colony on East Sand Island results in DCCO immigration from other areas, effects to other bird species in areas of DCCO emigration would be reduced. The same adaptive hazing plan as described in Alternative B would be used, but the need for hazing in the Columbia River Estuary and associated adverse effects would be lower, due to less DCCO dispersal.

Due to the potential for misidentification, the potential exists for take of pelagic cormorants during off-colony lethal take. During 16 years of diet studies on Rice and East Sand Island, in which 2,351 total DCCOs were lethally taken, take of 3 pelagic cormorants occurred during one year (BRNW 2013a). This is a take rate of 0.13 percent. Given the magnitude of take and different methodologies, higher take rates could occur under Alternative C. Under the 4-year lethal strategy, (15,956 DCCO taken in total; 5,230, 4,270, 3,533, and 2,923 DCCOs taken in years 1–4, respectively), and a 0.3 percent take rate of pelagic cormorants, which was determined from input by cooperating agencies, up to 48 (15,956 x 0.003) pelagic cormorants could be taken in total during years 1 to 4 under this scenario. Total take would be similar under the 3-year (15,790 DCCOs; 47 pelagic cormorants) and 2-year (15,386 DCCOs; 46 pelagic cormorants) strategies. The pelagic cormorant colony in the Columbia River Estuary is approximately 150 breeding individuals, which is approximately 0.5 percent of the Pacific Region population (29,000 breeding individuals; see Table 3-3). There is a potential for take of up to approximately 0.03 to 0.05 percent of the regional population of pelagic cormorants per year under the 4-year strategy, or up to 6 to 10 percent of the colony in the Columbia River Estuary per year. Take of 46 to 48 pelagic cormorants would have direct adverse effects on individuals and associated breeding pairs and likely limit or reduce the size of the pelagic cormorant colony in the Columbia River Estuary. However, this level of take would likely have negligible effects on the regional population (i.e., under the 4-year strategy, take of approximately 0.05 percent (16 individuals [5,230*0.005)/29,000[regional population]), 0.04 percent (13/29,000), 0.04 percent [11/29,000), and 0.03 percent (9/29,000) of the regional population during years 1–4, respectively). If DCCO take levels increase in subsequent years under adaptive management, take levels could be as high as 0.06 percent (18 individuals [6,071*0.005]/29,000]) of the regional population and 12 percent (18/150) of the colony in the Columbia River Estuary in year 2 under the adjusted 3-year lethal strategy or 0.1 percent (30 individuals [10,156*0.005]/29,000]) of the regional population and 20 percent (30/150) of the colony on East Sand Island in year 2 under the adjusted 2-year lethal strategy. Expected take levels would likely be lower, given the Adaptive Management approaches described in Chapter 2 to minimize take of non-target species. Additionally, the majority of lethal take would likely occur on-island, where potential for taking pelagic cormorants is very low.

Phase II - Adverse effects from DCCO dispersal and associated hazing would likely be lower in the short-term, compared to Phase I, but could become higher if DCCO dispersal increases after lethal take commences. Effects from modifying the terrain are the same as Phase II of Alternative B.

Alternative D

Phase I - Same as Alternative C.

Phase II - Additional dispersal of all remaining DCCOs from East Sand Island, approximately 5,600 breeding pairs, would occur. Effects to other birds would be commensurate with dispersal levels to new areas and subsequent site-specific interactions. Expected levels of dispersal and need for hazing in the Columbia River Estuary would be similar to Phase I of Alternative B, in the short-term. Potential effects would be high in both the short- and long-term if hazing cannot redistribute all DCCOs outside the Columbia River Estuary. There would be no effects in the long-term after all DCCOs are redistributed outside the Columbia River Estuary. Effects from modifying the terrain are the same as Phase II of Alternative B.

4.2.5 Effects to ESA-Listed Fish in Lower Columbia River Basin

The revised RPA 46 from the 2014 FCRPS Supplemental Biological Opinion projected that a colony size of approximately 5,600 DCCO breeding pairs would reduce the gap in steelhead and Chinook salmon survival and return DCCO predation rates to levels observed during the FCRPS base period (NOAA

2014). The NOAA Fisheries analysis (Appendix D) utilized bioenergetics data (described in Chapter 1, section 1.1.6) and estimated total available smolts in determining predation rates. This EIS adopts NOAA Fisheries analysis (see Chapter 1, section 1.2) and associated survival gap estimates, but proposes to use PIT tag recoveries in the future to evaluate management actions. PIT tags provide ESU or DPS specific estimation of predation rate, consistent with NOAA Fisheries (2014) directive to obtain stock-specific data when possible. Predation rates on ESA-listed Columbia River Basin ESUs or DPSs, using PIT tag recoveries on the East Sand Island DCCO colony over the last ten years, are provided in Chapter 3, section 3.2.5 and Appendix C.

Provided in this section are estimates of potential benefits (increases in survival) to ESA-listed juvenile salmonids using PIT tag data for the reductions in DCCO colony size, as proposed in the alternatives. Potential increases in survival differ from those presented by NOAA Fisheries in the 2014 FCRPS Biological Opinion (Appendix D) because: 1) different time periods were used to estimate fish effects; 2) different groups of fish were evaluated (e.g., NOAA Fisheries analyzed species-level impacts, not ESU or DPS-level impacts); and 3) different analytical methods (e.g., PIT tag predation rates versus absolute consumption rates) were used to estimate predation losses. As such, direct comparisons between NOAA Fisheries analysis (Appendix D) and those presented here should be made cautiously. Common elements of both analyses are a reduction in colony size to approximately 5,600 nesting pairs (Alternatives B-D, Phase I) and the use of per capita impacts to measure potential increases in fish survival rates.

Methods for Evaluating Benefits to Juvenile Salmonids

PIT tag data were available for 8 of 13 ESA-listed anadromous salmonid ESU or DPS that occur in the Lower Columbia River Basin. Impacts to ESA-listed juvenile salmonid ESU or DPS were estimated by dividing the average annual predation rate (see Appendix C) by the average annual DCCO colony size to generate an average annual per capita (per bird) predation rate. Per capita predation rates were generated during a ten year (2004-2013) reference period. To account for inter-annual variation observed in salmonid predation rates, per capita estimates were also generated for the lowest and highest annual predation rates observed during the reference period. Potential benefits (an increase in survival) were then estimated by multiplying the per capita predation rate by the colony size identified in Phases I and II of Alternatives A–D. Predation rate data were not available for all DPS or ESU evaluated during the 10-year reference period (2004-2013). Per capita predation rate impacts were generated for a 5-year reference period (2009-2013) for Snake River steelhead, a 7-year reference period (2007-2013) for Upper Willamette River Chinook and Middle Columbia River steelhead, and the entire 10-year reference period (2004-2013) for the remaining five ESU or DPS evaluated. Actual benefits to ESA-listed juvenile salmonids from DCCO management actions in the Columbia River Estuary would depend on a number of factors. The analysis presented here assumes that per capita salmonid impacts observed during the last decade, a constant rate applied over a range of biotic and abiotic conditions and fisheries management practices that affect juvenile salmon abundance, timing, and susceptibility to predation, would persist in the next decade. If this proves to be false, however, per capita impacts in the future could differ to an unknown degree.

Summary Tables of Potential Benefits

The tables below (Table 4-2, Table 4-3) provide potential increases in juvenile salmonid survival in the Columbia River Estuary if DCCO colony size on East Sand Island is reduced to levels identified in Phase I and Phase II of Alternatives A–D. Increases represent the average (lowest-highest) annual percent increase in juvenile survival.

TABLE 4-2. Potential Benefits (Survival Increase) to Select Juvenile Chinook ESUs from Alternatives.

	Snake River Spring/Summer Chinook		Snake River Fall Chinook		Upper Columbia River Spring Chinook		Upper Willamette River Spring Chinook	
Alternative	Phase I	Phase II	Phase I	Phase II	Phase I	Phase II	Phase I	Phase II
A	0%	0%	0%	0%	0%	0%	0%	0%
B	3% (1-4)	3% (1-4)	2% (1-3)	2% (1-3)	2% (1-3)	2% (1-3)	1% (0-2)	1% (0-2)
C	3% (1-4)	3% (1-4)	2% (1-3)	2% (1-3)	2% (1-3)	2% (1-3)	1% (0-2)	1% (0-2)
D	3% (1-4)	4% (2-7)	2% (1-3)	3% (2-5)	2% (1-3)	4% (2-6)	1% (0-2)	2% (0-4)

TABLE 4-3. Potential Benefits (Survival Increase) of Select Steelhead DPSs and Snake River Sockeye from Alternatives.

	Snake River Steelhead		Upper Columbia River Steelhead		Mid Columbia River Steelhead		Snake River Sockeye	
Alternative	Phase I	Phase II	Phase I	Phase II	Phase I	Phase II	Phase I	Phase II
A	0%	0%	0%	0%	0%	0%	0%	0%
B	4% (1-9)	4% (1-9)	4% (2-7)	4% (2-7)	4% (1-9)	4% (1-9)	2% (2-5)	2% (2-5)
C	4% (1-9)	4% (1-9)	4% (2-7)	4% (2-7)	4% (1-9)	4% (1-9)	2% (2-5)	2% (2-5)
D	4% (1-9)	8% (3-17)	4% (2-7)	6% (3-11)	4% (1-9)	8% (2-15)	2% (2-5)	4% (3-6)

In general, benefits from a reduction in DCCO colony size on East Sand Island are expected to be greater for steelhead compared with salmon ESUs. Comparisons of potential benefits within the same species (Chinook, steelhead, sockeye) by ESU or DPS indicate that juvenile salmonids originating from the Snake River Basin may receive the greatest benefit. Based on the lowest and highest annual predation rate observed during the reference period, results indicate that substantial deviation from the average benefit could be expected in any given year. For example, although average annual benefits to Snake River steelhead were estimated at 4 percent in any given year, the annual benefit could fall between 1 and 9 percent. Hence, average benefits should be realized over a course of many years, with annual benefits falling within the estimated range (1 to 9 percent). Additionally, smaller increases in juvenile salmonid survival than are presented in Tables 4-2 and 4-3 could occur, depending on the actual degree to which DCCOs greater than the target colony size can be completely excluded from the estuary and to the degree mortality is compensatory (see Chapter 4, section 4.6.5 for more discussion).

Alternative A

Under this alternative the Corps would take no action to reduce the rate of DCCO predation on juvenile salmonids. As habitat and available prey base are not limiting factors on East Sand Island, it is likely the DCCO colony would continue to cause significant mortality to juvenile salmonids in the estuary, comparable to recent levels. There would be no benefit in survival of juvenile salmonids from this alternative. Significant direct effects (i.e., mortality) and indirect effects (i.e., reduced numbers of juvenile salmonids entering the ocean, the large colony of DCCOs continuing to attract more piscivorous waterbirds to the island resulting in potential increases in predation impacts to juvenile salmonids) would continue and likely vary from year to year, similar to prior conditions.

Alternative B

Phase I - Direct benefits from a reduction in the current DCCO colony size could result in average annual survival increases of 1 to 4 percent, depending on ESU or DPS. However, benefits to juvenile salmonids under Phase I of Alternative B are not expected to be fully realized, at least in the short term, because benefits assume hazing efforts would be 100 percent successful in preventing DCCOs above the target colony size dispersed from East Sand Island from consuming juvenile salmonids in the Columbia River Estuary. Data from Collis et al. (2002) and Evans et al. (2012) indicate that per capita impacts to salmonid smolts were higher for DCCO nesting further upstream in the Columbia River Estuary and at an inland colony near the confluence of the Columbia and Snake rivers, compared with DCCOs nesting on East Sand Island. Impacts to juvenile salmonids may even be greater than was identified in the affected environment (Chapter 3, section 3.2.6) if a large number of DCCOs disperse and relocate in the estuary, particularly further upriver. The likelihood is high this could occur, given the magnitude of geographic scope, limited access to areas, and potential restrictions for hazing at some areas that are critical habitat for streaked horned larks. Predation rates would not be fully reduced until DCCOs dispersed from East Sand Island permanently emigrate away from the estuary.

Phase II - Same average annual survival increases as Phase I (1–4 percent depending on ESU or DPS). Similar to Phase I, benefits to juvenile salmonids under this alternative would not likely be fully realized until DCCOs that disperse from East Sand Island emigrate from the estuary. The proposed terrain modification has the potential to provide additional direct and indirect beneficial effects for juvenile salmonids. The ability to create tidal wetlands to indirectly support juveniles through the production and export of macrodetritis and prey is possible with terrain modification. More intertidal mudflats and marsh areas could support shallow water rearing habitat for juveniles. However, with a large DCCO colony (~5,600 nesting pairs) remaining on the island, there is potential that the terrain modification could attract juvenile salmonids and could increase mortality of juvenile salmonids at the local area.

Alternative C *(Preferred Alternative/Management Plan)*

Phase I - Same average annual survival increases of 1 to 4 percent (depending on ESU or DPS) as Alternative B. Benefits to juvenile salmonids are expected to be realized more quickly, because colony size reduction would occur primarily from lethal take and minimal dispersal is expected.

Phase II - Similar to Phase I. Benefits to juvenile salmonids are expected to be realized in the short-term because of limited DCCO dispersal from East Sand Island, but could decrease with time if dispersal increases. Direct and indirect benefits for juvenile salmonids associated with the terrain modification would be the same as Alternative B.

Alternative D

Phase I - Same as Alternative C.

Phase II - Complete exclusion of the DCCO colony on East Sand Island is expected to result in average annual survival increases of 2 to 8 percent, depending on ESU or DPS. Similar to Phase I of Alternative B, benefits would not be fully realized until all DCCOs emigrate from the Columbia River Estuary. Direct and indirect benefits associated with the terrain modification are the same as Phase II of Alternatives B and C. Benefits to juvenile salmonids would be the highest under this alternative and phase.

4.2.6 Effects to Other ESA-Listed Fish

ESA-listed fish species within the affected environment outside of the Columbia River Estuary that could be affected by DCCO predation were described in Chapter 3, section 3.2.7. With the exception of a few temporally limited studies within a few Oregon Coast estuaries, little to no empirical data are available to estimate rates of DCCO predation on these fish species. Predicting or quantifying these direct or indirect effects can be difficult or tenuous in open, complex systems, even with detailed study. In general, effects would be commensurate with DCCO dispersal levels to new areas and subsequent site-specific interactions.

DCCO impacts on ESA-listed fish are likely to be greater in freshwater and estuary habitats, where fish may be more densely concentrated and thus more vulnerable to avian predation (Lyons 2010; Adrean 2013). Impacts to ESA-listed fish from DCCO predation in each sub-region (i.e., Oregon Coast, Washington Coast, Salish Sea, and outer Vancouver Coast) would vary greatly, depending on numerous factors, including availability of alternative prey, fish behavior and life history characteristics, foraging range of DCCOs nesting or roosting at a specific location, and other factors. Conversely, at coastal sites, non-listed marine forage fish (e.g., anchovy, herring, surfperch, and numerous others) are usually abundant, and ESA-listed fish may be more dispersed in the ocean environment, factors that may buffer predation risks to ESA-listed fish in marine waters (Ainley and

Anderson 1981; Loeffler 1996; Collis et al. 2012). The potential impacts from DCCO predation would occur at the juvenile life stage for most ESA-listed fish in the affected environment, with the exception of Pacific eulachon, which, due to their small size, are susceptible to DCCO predation throughout their life cycle.

Alternative A

No change in the current conditions of DCCO predation of ESA-listed fish would be expected; DCCO dispersal and associated effects would likely be lower in the near-term than prior years when research was on-going.

Alternative B

Phase I - Approximately more than 7,250 DCCO breeding pairs would be redistributed outside the Columbia River Estuary. Effects to fish species outside the Columbia River Basin would be commensurate with DCCO dispersal levels to new areas and subsequent site-specific interactions. Pacific eulachon are believed to be widely distributed; however, there is little temporal overlap between the DCCO nesting season (April – September) and the eulachon spawning run, and juvenile eulachon may be too dispersed in the open ocean and deep in the water column to be susceptible to DCCO predation. Adverse impacts from DCCO redistribution are not expected. Specific areas in the affected environment, identified below, are likely to be more impacted by DCCO dispersal and a redistributed western population.

Oregon Coast - Oregon Coast Coho juveniles out-migrate as yearlings in the spring. Diet studies of DCCOs foraging in Tillamook Bay suggested DCCO consumed an estimated 8,000 out-migrating coho smolts in spring 2012, which equates to rough 4 percent of the hatchery and wild coho smolts available in the bay (Adrean 2013). Coho smolts along the northern Oregon Coast may also be vulnerable to DCCO predation in estuary environments, and estuaries with DCCO colonies exist in this sub-region (i.e., Rogue River Estuary, Oregon). Salmonids overall composed, on average, 35 percent of DCCO diet by biomass (Adrean 2013), indicating susceptibility of juvenile salmonids to DCCO predation in an Oregon estuary environment. Past dissuasion research and movement data have shown low levels of DCCOs from East Sand Island prospecting in Oregon. Effects to coastal coho juveniles could be higher if prior patterns change and DCCOs prospect for new nesting locations in Oregon.

Washington Coast / Salish Sea Areas - Based on their use of deep water habitat and large size at reproduction, interactions among bocaccio, canary and yelloweye rockfish, and DCCOs in the Salish Sea sub-region are likely minimal, and adverse effects are not expected, although larvae and juveniles may be more susceptible to DCCO predation. Bull trout susceptibility to DCCO predation may be greater for migratory fish compared with resident fish, especially for bull trout that utilize estuaries. Extended use of estuaries and nearshore marine environments by juvenile Puget Sound Chinook and juvenile Hood Canal chum suggests they would be more vulnerable to DCCO predation if DCCOs disperse to coastal estuaries in Washington. This seems more likely, based on movement data from dissuasion experiments. Puget Sound steelhead smolts may move offshore more quickly, as compared with Puget Sound Chinook and Hood Canal chum salmon (NOAA 2011a), and this would likely lessen their susceptibility to DCCO predation. Impacts to Ozette Lake sockeye are unknown but the potential for conflict exists, especially if sockeye use estuary or nearshore habitats for extended periods of time.

Phase II - The potential for DCCO dispersal would likely be high in both the short- and long-term as DCCO redistribute in the region. No effects to ESA-listed fish would occur from implementation of the terrain modification.

Alternative C *(Preferred Alternative/Management Plan)*

Phase I - Overall DCCO dispersal from East Sand Island is assumed to be minimal, compared to more than 7,250 DCCO breeding pairs considered under non-lethal management. Effects to ESA-listed fish species outside the Columbia River Basin would be commensurate with DCCO dispersal levels to new areas and subsequent site-specific interactions, but are assumed to be low. If abundance reduction of the DCCO colony on East Sand Island results in DCCO immigration from other areas, effects to fish species in areas of DCCO emigration would be reduced.

Phase II - Effects to fish species outside the Columbia River Basin would be commensurate with DCCO dispersal levels to new areas and subsequent site-specific interactions. Effects are assumed to be minor in the short-term but could become adverse if DCCO dispersal increases after lethal take commences. Effects from proposed terrain modification would be the same as Alternative B.

Alternative D

Phase I - Same as Alternative C.

Phase II - Additional dispersal of all remaining DCCOs from East Sand Island, approximately 5,600 breeding pairs, would occur. Effects to fish species outside the Columbia River Basin would be comparable to Phase I of Alternative B in the short-term and long-term. Effects from proposed terrain modification would be the same as Phase II of Alternatives B and C.

4.3 Socioeconomic Environment

This section addresses potential effects to social and economic resources from the proposed EIS alternatives, with the primary focus on in-river Columbia River tribal fisheries (4.3.2), commercial and recreational fisheries (4.3.3), public resources (4.3.4), and historic properties on East Sand Island (4.3.5).

4.3.1 Columbia River Basin Salmon Fisheries

An analysis was conducted to assess economic and social impacts to Columbia River Basin in-river salmonid fisheries resulting from reducing the size of the DCCO East Sand Island colony to the target size identified in the EIS alternatives (TRG 2014; see Appendix I for more details on methods and assumptions and description of the geographic area considered). A deterministic simulation model was developed to show relative effects among the proposed alternatives: the no action alternative (no change from current conditions), a reduction of the DCCO colony to approximately 5,600 breeding pairs (Alternatives B and C, and Phase I of Alternative D), and reduction of all DCCOs on East Sand Island (Phase II of Alternative D). Economic models were used to translate reduction of DCCO juvenile salmonid predation (i.e., increase in out-migrating smolts survival) to in-river fisheries economic impacts in the Columbia River Basin.

The no action or baseline condition (i.e., Alternative A) was determined using the following data inputs: 1) annual average 2000s broodstock survival to analyzed fisheries; 2) recent years' ocean and river harvest exploitation rates; 3) annual average 2008-2012 hatchery production; 4) estimated wild fish production, based on hatchery production ratio estimators; and 5) constant DCCO predation probabilities from a recent five-year annual average dataset. Gains in economic value from reduced DCCO predation were estimated using two approaches and analytical methodologies: 1) direct financial value for fishing industry sectors (commercial gillnet, tribal, and recreational sport); and 2) regional economic impacts. Direct financial value is revenue received by harvesters and expenditures made by anglers that are linked with the availability of Columbia River Basin production returning adults. A regional economic impacts analysis shows how the direct change in expenditures is multiplied throughout the regional economy. The measurement unit for regional economic impacts with the most bearing is personal income and jobs.

Direct financial value and regional economic impact measurements for EIS alternatives are shown by species and by the three industry sectors in Table 4-4 and Table 4-5. The modeled economic benefits represent the maximum value that can be achieved. Realized economic benefits would likely depend on the actual degree to which DCCOs can be excluded from estuary, the degree to which mortality is compensatory, and the potential for economic benefits to be offset by economic losses in other areas outside of the Columbia River Basin. The potential for economic offset would be greater under alternatives that promote DCCO dispersal (Alternative B and Alternative D, Phase II). Additionally, costs to implement given alternatives should also be considered when evaluating the expected net economic benefit of an alternative.

TABLE 4-4. Economic Effects from DCCO Predation Reduction to Columbia River In-river Fisheries by Sector and Species for Participant Direct Financial Value (DFV).

	Alternative A	**Effect (change from Alternative A)**			
		Alt B-C; Phase I, Alt D		**Phase II, Alt D**	
Fisheries	Amount (000's)	Change (000's)	% Differ.	Change (000's)	% Differ.
Freshwater sport	32,544	1,310	4.0%	2,340	7.2%
Coho	3,663	66	1.8%	117	3.2%
Chinook					
Spring/summer	4,597	100	2.2%	178	3.9%
Fall	7,118	128	1.8%	228	3.2%
Steelhead	17,120	1,017	5.9%	1,815	10.6%
Sockeye	47	1	2.5%	2	4.4%
Non-Indian commercial	4,259	83	2.0%	149	3.5%
Coho	761	14	1.8%	24	3.2%
Chinook					
Spring/summer	1,842	40	2.2%	71	3.9%
Fall	1,655	30	1.8%	53	3.2%
Steelhead	0	0		0	
Sockeye	1	0	2.5%	0	4.4%
Tribal commercial	4,149	89	2.2%	160	3.8%
Coho	104	2	1.8%	3	3.2%
Chinook					
Spring/summer	2,242	49	2.2%	87	3.9%
Fall	1,617	29	1.8%	52	3.2%
Steelhead	157	9	5.9%	17	10.6%
Sockeye	29	1	2.5%	1	4.4%
Total	40,951	1,483	3.6%	2,648	6.5%
Coho	4,528	81	1.8%	145	3.2%
Chinook					
Spring/summer	8,681	188	2.2%	336	3.9%
Fall	10,390	186	1.8%	332	3.2%
Steelhead	17,277	1,026	5.9%	1,832	10.6%
Sockeye	76	2	2.5%	3	4.4%

Notes:
1. Direct financial value (DFV) is commercial gillnet and tribal fisheries participant harvest revenue plus recreational angler trip expenditures.
2. DFV is in thousands of Year 2012 dollars adjusted using the GDP implicit price deflator developed by the U.S. Bureau of Economic Analysis.
3. Effects are model outcomes for alternatives' changed conditions minus status quo conditions.

TABLE 4-5. Economic Effects from DCCO Predation Reduction to Columbia River In-river Fisheries by Sector and Species for Regional Economic Impacts (REI).

		Effect (change from Alternative A)			
	Alternative A	Alt B-C; Phase I, Alt D		Phase II, Alt D	
Fisheries	Amount (000's)	Change (000's)	% Differ.	Change (000's)	% Differ.
Freshwater sport	33,200	1,171	3.5%	2,091	6.3%
Coho	2,734	49	1.8%	87	3.2%
Chinook					
Spring/summer	12,336	267	2.2%	477	3.9%
Fall	5,314	95	1.8%	170	3.2%
Steelhead	12,781	759	5.9%	1,355	10.6%
Sockeye	35	1	2.5%	2	4.4%
Non-Indian commercial	7,350	143	1.9%	255	3.5%
Coho	1,356	24	1.8%	43	3.2%
Chinook					
Spring/summer	2,993	65	2.2%	116	3.9%
Fall	2,998	54	1.8%	96	3.2%
Steelhead	0	0		0	
Sockeye	3	0	2.5%	0	4.4%
Tribal commercial	7,806	189	2.4%	337	4.3%
Coho	197	4	1.8%	6	3.2%
Chinook					
Spring/summer	3,721	81	2.2%	144	3.9%
Fall	2,922	52	1.8%	93	3.2%
Steelhead	823	49	5.9%	87	10.6%
Sockeye	143	4	2.5%	6	4.4%
Total	48,355	1,503	3.1%	2,683	5.5%
Coho	4,288	77	1.8%	137	3.2%
Chinook					
Spring/summer	19,049	412	2.2%	736	3.9%
Fall	11,233	201	1.8%	359	3.2%
Steelhead	13,604	808	5.9%	1,443	10.6%
Sockeye	181	4	2.5%	8	4.4%

Notes: 1. Regional economic impacts (REI) are expressed as personal income. REI is in thousands of Year 2012 dollars adjusted using the GDP implicit price deflator developed by the U.S. Bureau of Economic Analysis.
2. Effects are model outcomes for alternatives' changed conditions minus status quo conditions.

4.3.2 Effects to Tribal Fisheries

Native American tribes in certain Columbia River Basin geographic areas are particularly vulnerable to fishery-related changes, given the tribes' thousands of years of life dependency on Columbia River fish resources. The conditions creating the DCCO depredation issue result from post-European settlement, and the problem is additive to the drastic alteration from historic tribal fisheries. While the analysis in this section provided for a quantitative analysis for potential economic outcomes of DCCO management, it does not include value of tribal ceremonial and subsistence harvests, which cannot be measured in terms of dollars and are culturally significant beyond economic gain; thus, economic values given below only include tribal commercial fisheries (see Chapter 3, section 3.3.2 for additional information related to tribal fisheries, including ceremonial and subsistence harvests during 1998–2012).

Alternative A

No reduction of East Sand Island DCCO colony abundance or reduction in DCCO juvenile salmonid predation. Annual economic value of in-river Columbia River fisheries would likely remain similar to baseline conditions in the near-term for tribal commercial fisheries: direct financial value of $4.1 million and regional economic impact of $7.8 million. Predation by the DCCO colony on East Sand Island would likely continue to result in annual loss of 3.8 percent ($0.2 million) direct financial value and 4.3 percent ($0.3 million) regional economic impact to tribal fisheries.

Alternative B

DCCO colony abundance reduced to 5,600 breeding pairs during Phases I and II through primarily non-lethal methods. Annual direct financial value increases of 2.2 percent ($0.1 million); annual regional economic impact increases of 2.4 percent ($0.2 million). Economic benefits are not expected to be fully realized, at least in the short term, because benefits assume hazing efforts would be 100 percent successful in preventing DCCOs above the target colony size that are dispersed from East Sand Island from consuming juvenile salmonids in the Columbia River Estuary. Benefits would be fully realized once DCCOs dispersed from East Sand Island permanently emigrate away from the estuary.

Alternative C *(Preferred Alternative/Management Plan)*

Same economic increases as Alternative B; benefits are expected to be realized more quickly in Phase I because minimal dispersal is expected. In Phase II, benefits are expected to be realized in the short-term because of limited DCCO dispersal from East Sand Island, but could decrease with time if dispersal increases.

Alternative D

Annual economic increases would be similar to Alternative C in Phase I. In Phase II, annual direct financial value increases of 3.8 percent ($0.2 million); annual regional economic impact increases of 4.3 percent ($0.3 million). Economic benefits are not expected to be fully realized in the short-term. Benefits would be fully realized once DCCOs dispersed from East Sand Island permanently emigrate away from the estuary.

4.3.3 Effect to Recreational and Commercial Fisheries

Alternative A

No reduction of East Sand Island DCCO colony abundance or reduction in DCCO juvenile salmonid predation. Annual economic value of in-river Columbia River fisheries would likely remain similar to baseline conditions in the near-term for freshwater sport recreational fisheries: direct financial value of $32.5 million and regional economic impact of $33.2 million. Predation by the DCCO colony on East Sand Island would likely continue to result in annual loss of 7.2 percent ($2.3 million) direct financial value and 6.3 percent ($2.1 million) regional economic impact to freshwater sport recreational fisheries. Annual economic value of in-river Columbia River fisheries would likely remain similar to baseline conditions in the near-term for non-Indian commercial fisheries: direct financial value of $4.3 million and regional economic impact of $7.4 million. Predation by the DCCO colony on East Sand Island would likely continue to result in annual loss of 3.5 percent ($0.1 million) direct financial value and 3.5 percent ($0.3 million) regional economic impact to non-Indian commercial fisheries.

Alternative B

DCCO colony abundance reduced to 5,600 breeding pairs during Phase I and II through primarily non-lethal methods. For freshwater sport recreational fisheries, annual direct financial value increases of 4.0 percent ($1.3 million); annual regional economic impact increases of 3.5 percent ($1.2 million). For non-Indian commercial fisheries, annual direct financial value increases of 2.0 percent ($0.1 million); annual regional economic impact increases of 1.9 percent ($0.1 million). Economic benefits are not expected to be fully realized, at least in the short term, because benefits assume hazing efforts would be 100 percent successful in preventing DCCOs above the target colony size that are dispersed from East Sand Island from consuming juvenile salmonids in the Columbia River Estuary. Benefits would be fully realized once DCCOs dispersed from East Sand Island permanently emigrate away from the estuary.

Alternative C *(Preferred Alternative/Management Plan)*

Same economic increases as Alternative B; benefits are expected to be realized more quickly in Phase I because minimal dispersal is expected. In Phase II, benefits are expected to be realized in the short-term because of limited DCCO dispersal from East Sand Island, but could decrease with time if dispersal increases.

Alternative D

DCCO colony abundance reduced to 5,600 breeding pairs through primarily lethal methods during Phase I and non-lethal methods to disperse all remaining DCCOs in Phase II. Economic increases would be similar to Alternative C in Phase I. In Phase II, for freshwater sport recreational fisheries, annual direct financial value increases of 7.2 percent ($2.3 million); annual regional economic impact increases of 6.3 percent ($2.1 million). For non-Indian commercial fisheries, annual direct financial value increases of 3.5 percent ($0.1 million); annual regional economic impact increases of 3.5 percent ($0.3 million). Economic benefits are not expected to be fully realized in the short-term. Benefits would be fully realized once DCCOs dispersed from East Sand Island permanently emigrate away from the estuary.

4.3.4 Effects to Public Resources

Alternatives B (Phase I) and D (Phase II) propose redistributing more than 7,250 and 5,600 DCCO breeding pairs, respectively, through primarily non-lethal methods. These two alternatives have the greatest potential for effects to public resources. Based upon past dissuasion research, DCCOs displayed high site fidelity to East Sand Island and the nearby sites in the Columbia River Estuary (Roby et al. 2014). Thus, the transportation structure of most concern is the Astoria-Megler Bridge, as it could be impacted by DCCO abundance increase from management actions on East Sand Island. Potential for impacts to other transportation structures at dams and hatcheries and to public health would be greater under alternatives with greater DCCO dispersal, but actual impacts would depend on DCCO dispersal levels and site-specific interactions. Newcastle's disease has been present in juvenile DCCOs during many years of the past decade. However, there are no records of this disease being transmitted to humans, and the highly virulent form of the virus that can impact commercial poultry operations has never been detected. Research personnel on East Sand Island have documented no adverse health effects. Risk of adverse effects to field personnel on the island is low, but would be higher comparatively under greater levels of management on-site.

Alternative A

Direct or indirect adverse effects to public resources (public health and human safety, transportation facilities, dams and hatcheries) would be similar to past conditions before dissuasion research, which potentially increased dispersal of double-crested cormorants. The DCCO colony on East Sand Island would likely remain relatively stable at approximately 13,000 breeding pairs in the near term. Potential for future disease outbreak would be similar to prior levels with similar colony size, but potential transmission away from East Sand Island would be low. Discontinuing research and monitoring on the East Sand Island colony may prevent future increase of DCCOs at the Astoria Bridge, as the numbers of DCCOs increased during dissuasion experiments. This could be a beneficial effect for bridge maintenance and could prevent additional corrosion from DCCO guano. There would be no potential health risks to field researchers on East Sand Island, as DCCO research and management would be discontinued.

Alternative B

With dispersal of more than 7,250 DCCO breeding pairs during Phase I and high potential for lower, but sustained levels of DCCO dispersal during Phase II, there could be potential effects to public resources. Persistent DCCO use of the Astoria-Megler Bridge during the breeding season would likely be similar to or higher than use during past dissuasion research. During past research, thousands of DCCOs used and roosted on the bridge following hazing events, and the number of nesting pairs approximately quadrupled between 2010 (63 nests) and 2013 (231 nests). There is approximately 6 to 10 times more suitable nesting habitat on the bridge (OSU unpublished data; see Figure 4-8 for use area). With sustained DCCO dispersal from East Sand Island, it is likely that the DCCO breeding colony on the bridge could increase by this amount without hazing on the bridge, which could be difficult to effectively implement. Thus, adverse effects to the Astoria-Megler Bridge from DCCO guano corrosion could be high. Effects to other transportation structures and at dams and hatcheries would be commensurate with DCCO dispersal levels and subsequent site-specific interactions. No direct or indirect effects to public health and human safety are expected, as direct human contact with DCCOs or DCCO fecal matter would be minimal. Water cannons, noise, or visual deterrents (wires) would likely be used to deter DCCO nesting on transportation structures, dams, and hatcheries. Nesting concentration of the remaining 5,600 breeding pair DCCO colony would likely be higher than previously observed on East Sand Island, which could increase the potential for transmission of Newcastle's or other diseases among DCCOs on East Sand Island, and potentially to other areas and breeding colonies because of high levels of dispersal. The associated risk of spreading disease to other public resources is low. Potential health risks to field researchers would be low and similar to prior levels during dissuasion research.

FIGURE 4-8. Steel truss section of "Bent 164" on the Astoria-Megler Bridge that is most used by DCCOs.

Alternative C *(Preferred Alternative/Management Plan)*

DCCO dispersal would be minimal compared to more than 7,250 DCCO breeding pairs during Phase I, and low in the short-term, but could become higher during Phase II. Effects to the Astoria-Megler Bridge, other transportation structures, and at dams and hatcheries would be commensurate with DCCO dispersal levels and subsequent site-specific interactions, but is assumed to be low during Phase I and could increase during Phase II. Short-term DCCO displacement to the Astoria-Megler Bridge could occur when implementing lethal strategies during Phase I. Persistent DCCO use of the Astoria-Megler Bridge throughout the duration of the breeding season is expected to be low because primary implementation of lethal take would occur during a less than 2 to 3 week duration, and available habitat on East Sand Island would not be limited for returning DCCOs that temporarily displace. Associated risks of spreading disease to other public resources is low and would likely be lower than during prior dissuasion research because nesting concentration would be lower and low levels of dispersal are expected. Additionally, field personnel would remove carcasses on-island, some of which could have died of natural mortality, which would further reduce potential of disease transmission. Potential health risks to field researchers would be low. Field personnel would directly handle, bury, and potentially transport DCCO carcasses, but no associated health risks have been documented from such activities.

Because of the precautionary measures taken when implementing lethal take (see Chapter 2, section 2.1.3) and USDA-WS' record of safe conduct for similar efforts, risk to public safety would be low under Alternative C. To assure that all lethal techniques would not result in risk to human safety, personnel conducting lethal take would adhere to all safety standards of firearm operation and training as described in the USDA-WS' Policy Manual, Directive 2.615 (Firearm Use and Safety), Firearms Safety Training Manual, and local, state, and Federal regulations. A shooting protocol would be developed prior to implementation of lethal take, which would include specific measures to reduce risk to human safety. Off-island shooting with shotguns would have very low public safety concerns, as effective range is less than 100 m; shooting would not occur near shorelines where the public could be impacted or if other boats were in close vicinity. For on-island shooting, the island would be closed to public use during implementation, and any violations of the closure or interference to management activities would be enforced as specified in 18 U.S.C. 111. Shooters would be stationed from elevated vantage points when possible and ensure there is sufficient backdrop before shots are taken. Ammunition would be a frangible, subsonic, lead-free bullet. Because of the frangible nature there is minimal chance of ricochet as the bullet breaks apart at impact. In addition, slower subsonic ammunition would be used where feasible, which would cause the bullet to travel much less distance than standard ammunition due to its heavier weight and slower speed. Prior to and during lethal activities, observers would monitor areas for any potentially unsafe shooting situations, including the use of thermal vision or other devices to check for human presence in the vicinity of the island during night-time or other low visibility operations.

Alternative D

Same as Alternative C during Phase I. Dispersal of more than 5,600 DCCO breeding pairs in Phase II, similar to effects described for Phase I of Alternative B. Adverse effects to the Astoria-Megler Bridge from DCCO guano corrosion could be high during Phase II until all DCCOs redistributed outside the Columbia River Estuary. Effects to other transportation structures and at dams and hatcheries would be commensurate with DCCO dispersal levels and subsequent site-specific interactions and would be nil after all DCCOs redistributed outside the Columbia River Estuary. Potential health risks to field researchers on East Sand Island would be low, and there would be no risk once management discontinues after all DCCOs dispersed from East Sand Island.

4.3.5 Effects to Historic Properties

With each of the EIS action alternatives, some minor and temporary ground disturbing activities would occur over the majority of upland areas island-wide in Phase I. Past experience on East Sand Island has demonstrated that nest site fidelity (commitment) is high and, because of this, the Corps expects to implement an adaptive approach recognizing the potential need to haze over the entire island to achieve the desired target colony size. More intensive and ground disturbing activities would occur under Phase II with terrain modification, excavation of sand, and removal of riprap rock armor in the DCCO nesting area on the western portion of the island.

Alternative A

Under the no action alternative, no actions would occur as part of DCCO management and no efforts to archive or record historic properties would be made. Currently, public use of East Sand Island has been restricted during research efforts and to minimize impacts to nesting birds. Public accessibility to the island could change in the future if no action is taken to manage DCCO, and further consideration of potential effects to historic properties on the island could be done at that time. No actions to manage DCCOs would also mean no ground disturbance and no direct adverse effects would occur to historic properties.

Alternative B

Under the non-lethal management focus alternative in Phase I, the Corps would employ an adaptive approach to haze birds on the island, restricting habitat of DCCOs to one acre or less, depending upon nesting densities, using non-lethal methods. Many non-lethal methods to haze birds do not require any ground disturbing activity, such as human presence on the island using visual or noise deterrents. However, some methods would require some minor and temporary ground disturbance in upland areas on East Sand Island. This temporary habitat modification barrier method would involve placing 3- to 4-foot long wood lathes or stakes in sandy soils to a depth of approximately 12 inches in suitable nesting habitat. Stakes would be placed a minimum of 10 feet apart with flagging secured to the stakes and a rope interlaced between the stakes. This barrier is placed prior to nesting and colony establishment and would be removed at the end of the nesting season, before winter storms.

Additional minor and temporary ground disturbing activities would be the areas needed for the field personnel to stage activities, which includes installation of temporary foundational structures, including dissuasion fences, bird blinds, platforms, or temporary structures (weatherports) for field camp. Equipment necessary to support the activities would be transported by boat, off-loaded on the northern shore of the island, and moved along the northern shore. These temporary and minor ground-disturbing activities are expected to have no effect to historic properties on East Sand Island. Consultation with the Oregon State Historic Preservation Officer would be completed prior to conducting Phase I activities.

Phase II actions would include all of the Phase I efforts where needed, but could also expand in scope to allow for terrain modification, which would involve excavation of sand on the western portion of the island and some removal of the basalt rock armor along the southern shore to allow for frequent inundation of the island by tidal events and to prevent DCCO nesting. Up to 350,000 cubic yards of material would be excavated approximately 2 meters in depth and redistributed either in berms, which would be vegetated, between the pile dikes or deposited on the eastern portion of the island. Approximately 30,000 cubic yards of riprap would be delivered to the island and used to reinforce the island. The basalt rock armor is a historic property associated with early twentieth century navigation improvements in the Columbia River. Because removal of some of this rock is likely to occur under Phase II, the site may be adversely affected. One other historic site recorded on East Sand Island is within the area of excavation on the western portion. This site is the remains of an observation tower associated with the World War II Harbor Defense System. The observation tower may be left in place but inundated by tidal events.

Alternative C *(Preferred Alternative/Management Plan)* and Alternative D

Effects to historic properties under these alternatives would be the same as Alternative B. No indirect effects associated with the proposed alternatives are expected.

4.4 Cumulative Impacts

This section addresses the potential cumulative impacts to affected resources addressed in the previous sections of Chapter 4. Cumulative impacts result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency or person undertakes such other actions (40 CFR 1508.7). The scope of analysis for the EIS is at a large scale, and many of the affected resources described in Chapter 4 that would either be directly or indirectly impacted by the proposed alternatives were addressed at the population level, the range of which extends in geographic scope far beyond East Sand Island and, in some instances, beyond the affected environment.

Geographic scope for the affected resources in Section 4.4 is at the regional (flyway) population level for birds (pelicans, cormorants, terns, and gulls common to East Sand Island), at the watershed level for juvenile salmonids, at the Washington Coast and Columbia River islands population level for streaked horned larks, and at the mouth of the Columbia River for historic properties. The temporal scope is based on the duration of effects from the proposed alternatives, which is different for every affected resource. Some effects may be temporary or short lived (i.e., hazing a bird away from a foraging area) while others (i.e., reduction of colony through lethal removal) may have longer lasting beneficial impacts to ESA-listed Columbia River Basin juvenile salmonids, in terms of increased survival during out-migration.

Direct adverse effects from non-lethal management actions are expected to be greatest to DCCOs and Brandt's cormorants as loss of habitat for DCCO would also mean loss of habitat for Brandt's cormorants. Streaked horned larks are the non-target bird species of most concern for EIS alternatives off East Sand Island, as hazing activities in the Columbia River Estuary may likely become more intensified. Brandt's cormorants (and to a much lesser extent, pelagic cormorants) are the non-target species bird species of most concern for EIS alternatives that involve lethal take. This section focuses on salmon and steelhead populations in the Columbia River Basin, the western population of DCCOs, and the regional populations of other birds on East Sand Island and in the Columbia River Estuary where management actions such as monitoring and hazing is proposed and where direct and indirect effects were identified.

4.4.1 Past Actions

The Council on Environmental Quality (CEQ) issued a memorandum on June 24, 2005 regarding analysis of past actions. This memorandum states, "…agencies can conduct an adequate cumulative effects analysis by focusing on the current aggregate effects of past actions without delving into the historical details of individual past actions." Chapter 3, Affected Environment, characterizes the existing conditions of the affected resources more completely, and thus, only a brief summary of the aggregate effects of past actions on the affected resources is provided here.

Human Population Growth and Development along the Columbia River Basin

During the twentieth century, human-caused development (rural and urban development along the floodplain of the Columbia River and flow alteration and management of the Columbia River) is typically cited as a major cause affecting environmental conditions of the Columbia River Basin. Development of urban and rural areas, agriculture, timber harvests, commercial fisheries, canneries, and expansion of navigation and commercial development can generally be thought of in terms of increased impervious surfaces, pollutant loading from stormwater runoff originating in residential, commercial, industrial, and other land uses for economic development, habitat loss, and loss of genetic diversity, due to smaller population sizes.

Degraded habitat conditions, loss of habitat, overfishing, and construction of dams (see below) adversely affected salmon and steelhead populations, causing them to be listed under the ESA in the late twentieth century. The construction of the Astoria-Megler Bridge in 1966 was a major infrastructure improvement that promoted transportation and allowed for continued expansion of the residential, commercial, and industrial development along the Oregon and Washington coasts. Stormwater discharges associated with past development adversely affected water quality for fish and other aquatic organisms, causing disease, loss of forage opportunities, and lowered productivity. Expansion of impervious surface areas limits natural groundwater recharge and bisects habitat typically near rivers and floodplains where the majority of human development has occurred in the Columbia River Basin.

During the late nineteenth and early twentieth century, habitat loss from westward settlement and direct hunting of DCCOs and other wildlife species, in absence of environmental and wildlife laws, led to precipitous population declines. During the mid-twentieth century, environmental stressors, particularly widespread use of chlorinated hydrocarbons (e.g., DDT) as pesticides, which contaminated the DCCO forage base, continued loss of habitat, particularly along the coasts, and continued unregulated take, further reduced DCCO and many other migratory bird populations. This resulted in many species being listed under the MBTA or ESA (e.g., brown pelicans), led to restrictions or banning of some environmental pollutants, and created the impetus for, and implementation of, many waterbird conservation planning documents, monitoring programs, and conservation actions to improve populations. These efforts were largely successful in stabilizing, or, as in the case of DCCOs, causing dramatic population increases in the late twentieth century.

Management of the Columbia River (Dam Construction, Stabilization of the Navigation Channel, and Maintenance Dredging)

More than any other past action, the management of the Columbia River has most affected environmental conditions for the resources described in this document. Construction of dams on the Columbia River in the twentieth century has altered flow patterns, reduced the amount of habitat available for fish for spawning and rearing, and allowed for expansion of residential and commercial development along port towns of the Columbia River. Parallel to dam construction, stabilization efforts at the mouth of the Columbia River, starting during the late nineteenth century and concluded during the twentieth century, enabled more reliable commercial navigation, which made Portland a major port city and increased potential for development and population growth. The construction of jetties and associated stabilization efforts (including those on East Sand Island) realigned the ocean entrance to the Columbia River, established a consistent navigation channel, and significantly improved navigation (Figure 4-9; NOAA 2012).

FIGURE 4-9. Mouth of the Columbia River jetty system.

To operate and maintain the federal navigation channel, which was deepened in the early twenty-first century, routine dredging is necessary. Dredged material was deposited on islands along the Columbia River Estuary. In the early 1980s, a dredged disposal event on East Sand Island (Figure 4-10) created suitable habitat for Caspian terns, resulting in the first occurrence of Caspian terns observed nesting in the Lower Columbia River Estuary.

FIGURE 4-10. East Sand Island in 1981 (left) and in 1984 (right) after the dredge disposal event that created suitable nesting habitat for Caspian terns.

Over the last 30 years, Caspian terns and DCCOs nesting on two dredged disposal islands (East Sand Island and Rice Island) have exhibited exceptional growth, and their consumption of juvenile salmonids has risen to be a significant source of mortality for juvenile salmonids, considered one of the factors currently limiting recovery for some listed ESUs and DPSs. Most recently the upland dredged disposal areas on islands in the Columbia River have been recognized for providing suitable nesting habitat for the recently ESA-listed streaked horned lark. More recent actions in the late twentieth century and early twenty-first century, specific to the Columbia River Basin, thought to have contributed to DCCO and other piscivorous waterbird abundance increases, include creation of stable, permanent nesting habitat in the estuary and an increase of hatchery fish production and release into the Columbia River Basin at times that coincide with the nesting seasons of these species.

Columbia River Basin Salmon and Steelhead Conservation Planning

The decline of Columbia River Basin salmon and steelhead populations caused them to be listed under the ESA. In the late twentieth century and early twenty-first century, thirteen ESUs of Columbia River Basin salmon and steelhead were listed under the ESA. As a result of their listing, many actions have occurred to restore habitat, improve fish passage at the dams, and remove other barriers (i.e. undersized culverts at road crossings), improve water quality, and promote stormwater management plans to reduce discharge of pollutants associated with human development.

In the early twenty-first century, efforts to manage predators of salmon and steelhead began with the pike minnow program, sea lion removal, and avian predation management, which first concentrated on hazing piscivorous birds from the dams and then concentrated on moving Caspian terns from Rice Island to East Sand Island in early 2000. More recent past actions have focused on socially attracting Caspian terns from East Sand Island to constructed islands in the Pacific flyway and on conducting dissuasion experiments on DCCOs nesting on East Sand Island.

Colonial Waterbird Conservation Planning

For a comprehensive review of colonial waterbird conservation in the United States, see Kushlan (2012). The roots of colonial waterbird conservation can be traced back to the birth of the conservation movement as a whole in the late nineteenth and early twentieth century. Early conservation efforts were led by the American Ornithologists Union and the Audubon Society (whose emblem is a Great Egret) to protect colonial waterbirds from human exploitation and the plume trade. The first conservation area of what would later become the National Wildlife Refuge System, Pelican Island in Florida, was established to protect a Brown pelican colony.

Throughout the early and mid-twentieth century, study and knowledge of colonial waterbirds increased through an assortment of primarily natural history studies, but systematic conservation, monitoring, and management did not gain hold, as it did so with game management in the 1920s and 1930s and waterfowl management in the 1940s. Colonial waterbirds became a conservation focal species in regards to pesticide use and pollutants during the 1960s and 1970s, which prompted some regional waterbird conservation efforts and monitoring. The first ever large-scale inventory of colonial wading bird nesting sites was conducted in 1975 along the east coast of the United States, and other state or local efforts, such as the Texas Waterbird Survey and bi-national Great Lakes Surveys, came into being during this time. Additionally, professional organizations concerning colonial waterbirds, such as the Colonial Waterbird Society (later the Waterbird Society) and the Pacific Seabird Group, formed during this period. During the 1980s and 1990s, large-scale national and continental conservation and planning efforts for various bird species, other than for colonial waterbirds, came about, including the North American Waterfowl Management Plan (1986) and advent of the Joint Ventures (1987), Partners in Flight (early 1990s), and the U.S. Shorebird Conservation Plan (late 1990s). In 2002, the North American Waterbird Conservation Plan was developed (Kushlan et al. 2002) and later broadened in scope to become the Waterbird Conservation for the Americas (see Waterbird Conservation for the Americas 2012). More recently, there have been efforts to align focus of all bird conservation across North America (see North American Bird Conservation Initiative 2012).

Currently, funding and monitoring efforts for waterbird conservation come from a diverse amalgam of Federal, state, NGO, private, and other agencies and organizations, and monitoring occurs under an assortment of national, regional, state, and local monitoring programs. Larger or regional colonial waterbird monitoring surveys within the Pacific Region are the Western

Colonial Waterbird Survey (USFWS 2008) and any continued or appended state monitoring programs, USFWS coastal helicopter and boat surveys, and monitoring strategies for the Pacific Flyway. There is no national or multi-national monitoring program or central repository for colonial waterbird data, although efforts to do so were originally initiated in the 1970s. Christmas Bird Count and Breeding Bird Survey data are still used often to assess long-term trends of these species, but the designs of these surveys are ill fitting for colonial waterbirds.

4.4.2 Present and Reasonably Foreseeable Future Actions

The following general categories of actions are ongoing present or reasonably foreseeable future actions that continue to contribute and are expected to continue to contribute to environmental conditions for the affected resources. Some present actions, like human population growth and development, or conservation planning efforts for salmon and steelhead, are a continuation of past actions or historic trends. Consideration of reasonably foreseeable future actions was given only to proposals that have been approved or funded or are highly probable given trends.

Human Population Growth and Development along the Columbia River Basin

Approximately 6 million people live in the Columbia River Basin, concentrated largely in urban parts of the lower Columbia River and the Willamette Valley. The population is presently expanding and is likely to continue to grow in the foreseeable future. Human population growth and development can be expressed as potential increases in discharges of pollutants in stormwater runoff from residential, commercial, industrial, agricultural, recreational, and transportation land uses. These are all sources of contaminants that currently degrade water quality.

Recent trends in design and regulation include more context-sensitive design through regional planning processes, which promote more open spaces and require stormwater treatment for new construction.

Effects — There is no way to quantify future contaminants as a result of increased human population and development, but it is reasonable to assume the level of demand for residential, commercial, industrial, and other land uses that produce stormwater runoff would continue along similar historical trends.

Management of the Columbia River

The management of streamflow on the Columbia River and its tributaries is presently occurring and is a reasonably foreseeable future action that contributes to environmental conditions affecting the resources described in this EIS. A series of 60 major dams and reservoirs are operated throughout the basin, including 31 federally owned projects that comprise the FCRPS. To maintain the federal navigation channel, the Corps annually dredges portions of the Columbia River to the Bonneville Dam, in order to maintain a depth sufficient to allow for commercial navigation, and disposes of dredged material on estuary islands (Figure 4-11). The Corps maintains the jetties and other navigational structures in the mouth of the Columbia River. The jetties are considered eligible for the National Register of Historic Places. Continued maintenance of the jetties is a reasonably foreseeable future action. The consequences of jetty failure (a breach through either jetty) would be rapid and lead to significant degradation of navigation through the mouth of the Columbia River.

Effects — Placement of dredged material on upland sites in the Columbia River Estuary creates potential nesting habitat for avian species, such as terns and cormorants. Repair work for the jetties enables navigation and provides for the most secure passage through the mouth of the Columbia River. Impacts from the repairs of the jetties are not expected to affect National Register eligibility, as their significance derives from historical events and their original alignment. Several years after placement disposal, sites become suitable habitat for streaked horned larks. Continuous placement and site preparation can allow for alternate reduction and creation of suitable nesting habitat on islands designated critical habitat for the larks.

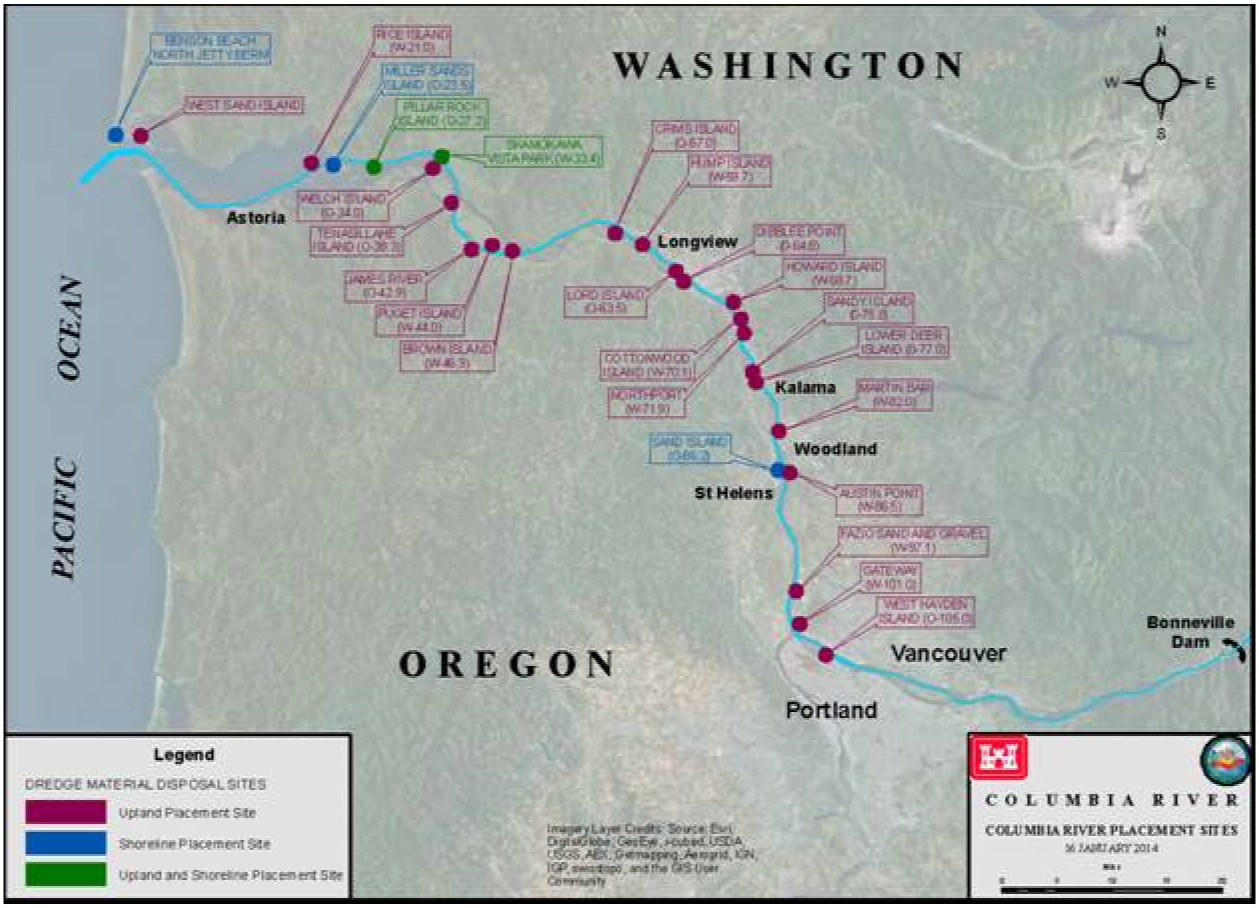


FIGURE 4-11. Upland and shoreline dredged material site network.

Management of DCCOs in the Western Population

The following actions are presently occurring and are reasonably foreseeable future actions concerning take of DCCOs within the western population. The USFWS annually issues take authority of DCCOs via depredation permits and scientific collection permits (an average of approximately 2,270 individuals; fewer DCCOs per year are actually taken). This level of take was included in the population model effects analysis (See Appendix E-2). Site-specific management of DCCOs within states of the Pacific Flyway include: 1) use of lethal take to support hazing DCCOs from dams, hatcheries, aquaculture facilities, and transportation structures (i.e., bridges, docks, marinas); 2) ODFW and other organizations conduct hazing efforts in the Oregon coastal estuaries, including boat-based hazing in April and May, to discourage DCCO from foraging; and 3) ODFW diet studies to quantify predation impacts to fish of conservation concern. Both the ODFW hazing program and diet studies are likely to continue. Lethal take for diet studies of East Sand Island DCCOs (approximately less than 150 individuals per year) would cease.

Effects — Direct effects of management of DCCOs include precluding DCCOs from optimal areas and adverse effects from disturbance. Mortality of individuals would occur during authorized lethal take management and research. Indirect effects are decreases in individual fitness, survival, or fecundity from exclusion from areas and hazing.

Other Avian Predation Management Actions in Columbia River Basin

The following actions are presently occurring and are reasonably foreseeable future actions concerning management of other piscivorous waterbirds (avian predators). Management would continue to reduce nesting acreage and size of the East Sand Island Caspian tern colony and disperse them outside the Columbia River Estuary. Actions include habitat modification and installing dissuasion materials outside of their designated colony areas on East Sand Island to achieve a target colony of approximately 3,000 breeding pairs of terns. Monitoring Caspian terns, hazing Caspian terns with human disturbance or placing dissuasion materials, and collecting up to 100 Caspian tern eggs from lower estuary islands (Rice, Miller Sands, and Pillar Rock Islands) would likely continue in the future. Hazing activities and effects to terns and non-target species (i.e. streaked horned larks, American white pelicans) occur annually during the breeding season with boat-based or pedestrian surveys beginning in mid-April and lasting until mid-June. Hazing and modifying habitat with dissuasion materials occurs to prevent approximately 400 pairs of Caspian terns from nesting on Goose Island in the Columbia Plateau. Annual hazing and lethal removal of gulls occurs to prevent consumption of juvenile salmonids at the lower Snake and Columbia River dams.

Effects — Direct effects include loss of Caspian tern nesting habitat and productivity as a result of hazing and modifying habitat, mortality of individuals from issuance and execution of depredation permits or scientific collection permits, and other adverse effects from disturbance. Indirect effects to species referenced above are decreases in individual fitness, survival, or fecundity from exclusion of optimal foraging or nesting areas.

Columbia River Basin Salmon and Steelhead Restoration and Recovery Efforts

Restoring the runs of Columbia River salmon and steelhead continues to be a regional priority. Numerous actions are currently being implemented or would be implemented in the foreseeable future, resulting from ESA consultations and biological opinions. These consultations result in terms and conditions or as design criteria for programmatic biological opinions, and function to improve stormwater management, promote habitat restoration, and improve fish passage to critical habitat. Reforms of harvest practices are underway to protect, rebuild, and enhance Columbia River fish runs, while providing harvest for treaty Indian fisheries and non-treaty fisheries. Implementation of Hatchery and Genetic Management Plans to update hatchery practices to best support recovery of ESA-listed salmonids is ongoing.

Effects — Water quality is improved through enforced and optional stormwater management. Estuary and stream habitat is restored and rearing and spawning habitats increase in complexity, which improve salmonid fitness and increase abundance. Structural improvements at the dams improve downstream passage and increase survival and overall abundance of juveniles in the estuary. Hatchery reforms improve broodstock management and reduce unintentional straying of hatchery fish into known wild fish spawning and rearing areas. With long-term increases of returning salmon, there would be an increase of ocean-source energy (i.e., converted to weight gain on salmon) coming back to the terrestrial system, which provides energy inputs into those food webs, ecosystems, etc.

Maintenance of the Astoria-Megler Bridge

The Oregon Department of Transportation (ODOT) actively maintains the Astoria-Megler Bridge by re-painting the structure above the guardrails and rehabilitating steel components of the bridge as required. Phase 1 of a multi-year maintenance program began in March 2012. Maintenance is to be completed December 2015 and involves coating all steel above the deck of the highway. Phase 2 involves coating all steel below the deck of the highway. The expected construction timing is 1 year from January 2016 through December 2016. Due to the numbers of DCCOs and pelagic cormorants that use the bridge, ODOT implements a hazing program to clear the bridge of migratory birds prior to maintenance activities. Depending upon the efficacy of hazing, a federal Migratory Bird Permit may be requested to implement activities after the nesting season.

Effects — Direct effects include loss of DCCO and pelagic cormorant nesting habitat and productivity as a result of hazing and modifying habitat, mortality of individuals from issuance and execution of depredation permits or scientific collection permits, and other adverse effects from disturbance. Indirect effects to species referenced above are a decrease in individual fitness, survival, or fecundity from exclusion of optimal foraging or nesting areas.

4.4.3 Cumulative Effects from the Proposed Alternatives

Alternative A

Alternative A would maintain baseline conditions for the East Sand Island DCCO colony, and DCCO depredation impacts to juvenile salmonids in the Columbia River Estuary would continue.

Cumulative Effects of Alternative A — Current baseline environmental conditions, as described in the affected environment, would not change for any of the affected resources (East Sand

Island colonial waterbirds, Columbia River Estuary birds, public resources, historic properties, fisheries, or Columbia River Basin juvenile salmon and steelhead). As a result of no change in the current baseline predation, impacts on juvenile salmonids from DCCO predation would remain significant and possibly increase if the DCCO colony on East Sand Island increases in the future. It is not known if other salmon recovery efforts would be undertaken or if they would be adequate to compensate for the large source of mortality.

The DCCO colony would likely remain the largest colony in western North America and the vast numbers of colonial waterbirds would continue to attract other birds seeking roosting, foraging, or nesting opportunities. A no action alternative could increase the risk that individuals, at some point in the future, may use illegal measures to reduce or attempt to reduce the DCCO colony on East Sand Island.

Alternative B

Alternative B would reduce the East Sand Island DCCO colony from baseline conditions to approximately 5,600 breeding pairs (approximate 1997 to 1998 abundance) through primarily non-lethal methods. Abundance of the western population of DCCOs would not be directly reduced, but future growth could be. The target colony size would be maintained through primarily non-lethal methods.

Cumulative Effects of Alternative B — Reduction of a significant point-source mortality factor of Columbia River juvenile salmonids (DCCO predation) would cumulatively contribute to other efforts that are improving the health and viability of these fish populations. A broad labyrinth of regulatory, monitoring, conservation, and restoration measures aimed at salmon recovery have been instituted which have stabilized or increased Columbia River salmonid population since the lows of the 1990s. Elimination or reduction of identified threats or bottlenecks to population growth, in conjunction with continued accumulation of knowledge, would likely increase Columbia River salmonid population viability and abundance. Increases in Columbia River salmonids would have positive impacts to affected fisheries and economies. Continued environmental demands and potential cumulative environmental degradation, associated with population increase along the Columbia River, would limit, to some extent, salmonid recovery efforts. Additionally, the void created by decreasing one mortality factor (DCCO predation) could be filled, to some extent, by other predators of juvenile salmonids, resulting in potential abundance increases of other predatory species.

Abundance of the western population of DCCOs would not be directly reduced under Alternative B. Future growth of the western population of DCCOs could likely be decreased compared to baseline conditions because of an initial decrease in productivity until DCCOs dispersed from East Sand Island find new breeding sites and limiting of future growth at East Sand Island. Based on generalist foraging and nesting behavior and adaptability of DCCOs, past growth rate of the western population of DCCOs, and environmental, regulatory, and waterbird management changes favorable to DCCO population expansion over the past decades, future growth over time could return to rates similar to baseline conditions.

Dispersal of more than 7,250 DCCO breeding pairs from East Sand Island would result in a more even distribution of the western population of DCCOs. The number of localized areas outside of the Columbia River Basin with perceived or real DCCO-fish conflicts would increase. More effort would be devoted toward DCCO monitoring and management in these areas, in regard to both time and resources. More depredation permit applications would likely be requested in more areas, compared to baseline conditions. Monitoring proposed under this alternative and future local and regional monitoring would contribute cumulatively to increased fossil fuel consumption and carbon dioxide emissions. Greater certainty about abundance and distribution of the western population of DCCOs would exist, with increased coordinated regional monitoring and abundance tied more closely to management objectives. DCCO dispersal and related hazing efforts, combined with existing hazing efforts from the Corps' Channels and Harbors Operation and Maintenance Program in the Columbia River Estuary, would likely limit other species' use of these areas. These activities could diminish cumulative efforts aimed toward streaked horned lark recovery in the estuary. Persistent DCCO use of the Astoria-Megler Bridge and corrosion from DCCO guano would increase the frequency and extent of maintenance. Hazing DCCO at the bridge would supplement ODOT's hazing program and could mean increased adverse effects to pelagic cormorants and DCCOs.

The proposed terrain modification on East Sand Island would have no cumulative impacts to vessel navigation of the Columbia River. The primary criteria of any terrain modification would be maintaining the integrity of navigation channels. Any displaced soil would be relocated to areas that would not negatively impact navigation. Terrain modification would likely reduce overall nesting waterbird use of East Sand Island, but would benefit and increase usage of species that require marsh, mudflat, and inundated beach habitat. Species diversity on East Sand Island would likely increase. Less nutrient loading into the Columbia River Estuary would occur with decreased nesting waterbird abundance on East Sand Island. The basalt rock armor on the shoreline would be directly affected by the terrain modification, but cumulative effects from other proposed maintenance of navigation structures in the Columbia River would be reviewed by architectural historians, and, overall, effects to the various elements associated with the history of navigation improvements in the mouth of the Columbia River are expected to be negligible, as they would be independently reviewed.

Alternative C *(Preferred Alternative/Management Plan)*

Alternative C would reduce the East Sand Island DCCO colony from baseline conditions to approximately 5,600 breeding pairs (approximate 1997 to 1998 abundance) through primarily lethal methods. Abundance of the western population of DCCOs would be directly reduced and is expected to be approximately 2,500 breeding pairs greater than ca. 1990 level after Phase I. Future growth could be potentially reduced. Target colony size would be maintained through primarily non-lethal methods.

Cumulative Effects of Alternative C — Reduction of DCCO predation would increase, to some extent, viability and abundance of salmonid populations in the Columbia River, and affected fisheries and economies, as described in Alternative B. DCCO dispersal would be minimal in the Columbia River Estuary, and certainty of benefits occurring to juvenile salmonids would be greater in the short-term. Over a long time horizon, though, methods of achieving a particular target size would be inconsequential, assuming dynamics of the colony would become equal over time.

Abundance of the western population of DCCOs is expected to be reduced to 2,500 breeding pairs greater than ca. 1990 level under Alternative C and future growth could be potentially reduced. Abundance of the western population of DCCOs would likely be less than baseline conditions during the next decades. Based on generalist foraging and nesting behavior and adaptability of DCCOs, past growth rate of the western population of DCCOs, environmental, regulatory, and waterbird management changes favorable to DCCO population expansion over the past decades, and prior examples of DCCO culling programs throughout the U.S. and Canada and great cormorant populations in Europe, future growth of the western population of DCCOs over time could return to rates similar to baseline conditions. Distribution of the western population of DCCOs would be less concentrated at the East Sand Island colony.

With minimal dispersal, no cumulative effects to fisheries or species in other areas or to the Astoria-Megler Bridge would be expected. Regional abundance of Brandt's and pelagic cormorants would likely remain similar to current abundance in the near term and continue along prior observed population trends. EIS actions would have negligible affects to these species because colonies in the Columbia River Estuary compose a very small percentage of their regional populations (Brandt's cormorants [approximately 4 percent]; pelagic cormorants [0.5 percent]) and upper levels of potential take are a negligible percentage of the regional populations (0.4 percent and 0.1 percent, respectively). Likewise, DCCO-fish conflicts and requested number of depredation permit applications outside of the Columbia River Estuary would be similar to the baseline conditions. Fossil fuel consumption would occur and contribute cumulatively to global warming, but levels of fuel consumption would be less than described in

Alternative B. Cumulative effects from terrain modification would be the same as described in Alternative B.

Alternative D

Alternative D would reduce the East Sand Island DCCO colony from baseline conditions to approximately 5,600 breeding pairs (approximate 1997 and 1998 abundance) through primarily lethal methods. Abundance of the western population of DCCOs would be directly reduced and is expected to be 2,500 breeding pairs greater than ca. 1990 level after Phase I. All DCCOs (remaining approximate 5,600 breeding pairs) would then be excluded from nesting on East Sand Island through primarily non-lethal methods. Future growth of the western population of DCCOs could be potentially reduced.

Cumulative Effects of Alternative D — No DCCOs nesting on East Sand Island would increase, to the greatest extent of the alternatives considered, viability and abundance of salmonid populations in the Columbia River and affected fisheries and economies. No DCCOs nesting on East Sand Island could also reduce attraction, and thus, abundance of other nesting waterbird species. This would result in an additional decrease of avian predation of juvenile salmonids (i.e., additional benefits to salmonids) and less nutrient inputs into the Columbia River from DCCO guano than baseline conditions.

Similar to Alternative C, abundance of the western population of DCCOs would likely be less than baseline conditions during the next decades and future growth could be reduced. Complete elimination of East Sand Island as a DCCO breeding colony and dispersal of approximately 5,600 breeding pairs could likely further reduce future growth compared to Alternative C. Future growth of the western population of DCCOs over time could return to rates similar to baseline conditions. Distribution of the western population of DCCOs would be more even than baseline conditions. The number of localized areas outside of the Columbia River Basin with perceived or real DCCO-fish conflicts would likely increase. More depredation permit applications would likely be requested in more areas than baseline conditions.

Dispersal in Phase II would have similar effects as those described in Phase I of Alternative B. With high levels of DCCO dispersal, cumulative effects to fisheries outside the Columbia River Estuary, the Astoria-Megler Bridge, streaked horned lark, and other species would be similar to Alternative B. Fossil fuel consumption would occur and contribute cumulatively to global warming; levels of fuel consumption would be similar to Alternative B. Cumulative effects from terrain modification would be the same as those described in Alternative B.

4.5 Climate Change

This section of this EIS was designed to address relevant points in recent climate change guidance and policy documents (Section 4.5.1). The literature review (Sections 4.5.2 and 4.5.3) qualitatively indicates which of the many potential climate change impacts on both inland and coastal physical processes are likely to be of importance to DCCO predation near the mouth of the Columbia River, focusing on changes in habitat at East Sand Island. The literature review incorporates reference historical analyses and uses the best available science and models. The analysis in Section 4.5.4 quantitatively assesses multiple sea level rise scenarios for the existing conditions and terrain modification proposed under Phase II of the action alternatives per CEQ guidance and using Corps methods. Specifically, the analysis examines changes in inundation that might directly affect avian behavior or indirectly affect avian species through habitat changes, based on a set of metrics developed specifically for this EIS. Section 4.5.5 provides a summary of the analysis.

4.5.1 Policy Direction

There are four recent documents guiding climate change impact assessment for this EIS. The CEQ has issued draft guidance that explains how climate change adaptation can be incorporated into NEPA processes. The Corps has issued policies documenting the four major climate change drivers affecting mission and operations and has provided engineering guidance for addressing sea level rise in coastal project planning.

Council on Environmental Quality and Corps Guidance on Integrating Climate Change in Federal Projects

The incorporation of climate change into federal agency planning processes has rapidly evolved in recent years. Executive Order 13514 and subsequent guidance from the CEQ (CEQ 2011a, 2011b) led to the development of USACE policy and planning documents. As a result, the Corps has developed the *Climate Change Adaptation Policy Statement* (USACE 2011a) and the *Climate Change Adaptation Plan and Report* (USACE 2012, 2013a). The policy states, "Mainstreaming climate change adaptation means that it will be considered at every step in the project lifecycle for all Corps projects, both existing and planned . . . to reduce vulnerabilities and to enhance the resilience of our water resource infrastructure."

Two recent CEQ guidance documents (*Principles and Requirements for Federal Investments in Water Resources* and *Interagency Guidelines for Federal Investments in Water Resources*) recommend that climate change adaptation processes be incorporated into NEPA processes to avoid instituting parallel planning (CEQ 2013a, 2013b). According to this guidance, climate change can be accounted by: 1) forecasting the key assumptions of future conditions; 2) characterizing the degree of uncertainty; 3) using multiple baselines; 4) accounting for changes resulting from a changing climate, including hydrologic and other conditions, increases in temporal and spatial variability of precipitation and water availability, and inundation in coastal areas; 5) using historical records and best available models to forecast projected future condition; and 6) giving particular consideration of climate change to long lived projects (CEQ 2013b). The draft guidance encourages using the best available science to forecast the effects of climate change "to enable evaluation of each alternative's impacts on ecosystem resilience, the sustainability of critical ecosystem services, and the vulnerability of human and natural systems to climate change" (CEQ 2013b). Accordingly, it is the policy of the Corps to use the best available and actionable climate science and climate change information in all long-term planning, prioritization, and decision making (USACE 2011a).

Corps Policies on Sea Level Rise and Coastal Areas

The Corps has developed policies for sea level rise engineering and adaptation that are consistent with all six elements outlined by the CEQ draft guidance, and these were used to address climate change effects in this document. In 2009, the Corps (working with NOAA's National Ocean Service and the U.S. Geological Survey) established policy guidance for estimating the effects of sea level rise in project planning (USACE 2009), based on a 1987 National Research Council Report, *Responding to Changes in Sea Level: Engineering Implications* (NRC 1987; USACE 2012; Tebaldi et al. 2012).

The National Research Council report recommended that coastal project planning account for uncertainties about accelerating sea level rise during project design life using multiple scenarios, representing 0.5, 1.0 and 1.5-m increases in eustatic (global) sea level by the year 2100. The report provided an equation for the global contribution to relative sea level rise (NRC 1987, p. 28). The total relative sea level rise above present levels, at a given year in the future, is the sum of two components, the global and local; the local component varies from land subsidence (as land subsides, relative sea level increases) to land uplift (which counters the effects of global sea level rise; NRC 1987). The Corps updated its guidance for project planning in 2011 to adjust the historical global mean sea-level change rate from 1.2 mm/yr (NRC 1987) to 1.7 mm/yr and to incorporate the midpoint (1992) of the most recent National Tidal Datum Epoch of 1983-2001 (USACE 2011b).

The type of scenario-based planning encapsulated in the Corps' guidance (2009; 2011b; USACE 2013a) continues to be recommended today. In 2013, adaptation to sea level rise began to be incorporated in project planning, design, and implementation (USACE 2013a). On December 31, 2013, the Corps issued an Engineering Regulation (ER) 1100-2-8162 (USACE 2013b). This new regulation continues to rely on the NRC (1987) approach, utilizing the 1.7 mm/yr rate of change in global mean sea level and integrating local historical tide gage records.

In general, national policies regarding the effects of climate change on inland hydrology and coastal storm effects are less developed than those for sea level rise. Through a high-level vulnerability assessment, the Corps identified four categories of climate change effects with the potential to impact its national mission and operations in its *2013 Climate Change Adaptation Plan* (USACE 2013a). These four categories are: 1) increasing air temperature; 2) changing precipitation; 3) increases in extreme events; and 4) sea level change and associated tides, waves, and surges (Table 4-6). Though it is understood that the greatest coastal damage generally occurs when high waves, storm surge, and high tide occur together, there is not a consensus regarding how the frequency and magnitude of storms may change on United States coasts (Parris et al. 2012).

4.5.2 Literature Review Relevant to Climate Change Policy

This section contains a summary review of key synthesis reports on the effects of climate change on physical processes in the Pacific Northwest relevant to this EIS. This is followed by the results of a literature review on the possible effects of these physical changes on DCCO predation of juvenile salmon and steelhead.

Climate Change Effects in Physical Processes

The physical processes in both the ocean and the Columbia River Basin affect East Sand Island, due to its proximity to the eastern Pacific Ocean, within the estuary of the second largest coastal river in the continental United States (as measured by discharge). Therefore, all four categories of effects identified by the Corps (increasing air temperatures; changing precipitation; increases in extreme events; sea level change and associated tides, waves, and surges) are active on the island (Table 4-6). Astronomical tides and coastal processes primarily affect water levels at East Sand Island. Of the total variance in water level in the lower 60 km of the Columbia River, weather contributes only 2 to 4 percent, and river flow 5 to 15 percent of the total variance in the water level regime, while tidal processes account for more than 60 percent (Jay et al. in revision).

TABLE 4-6. Four Categories of Projected Climate Change, with the Associated Potential Impacts and Potential Corps Vulnerabilities and Opportunities, Extracted from the 2013 Climate Change Adaptation Plan (USACE 2013a). Additional sources included are specific to the Pacific Northwest and the Columbia Basin.

Potential Impacts*	Potential Corps Vulnerabilities/Opportunities	Regional References
Increasing air temperatures		
Increases to average temperature, which will vary regionally and over time; increasing frequency and intensity of extreme heat; increasing length of frost-free season; changes in form of precipitation (snow vs. rain); reduced ice volume and extent on lakes, rivers, oceans, and in glaciers; changes in water and energy demand; altered habitat suitability; increasing water temperature and associated lake stratification and water quality; changes in invasive species or pest distribution; warmer sea surface temperatures and potentially altered circulation patterns; changed evapotranspiration impacting reservoirs and soil moisture.	Altered environmental windows; greater uncertainty of water supply and demand affecting navigation, ecosystem restoration, hydropower, recreation, and water supply; potential for coastal extreme high water events associated with altered ocean circulation; threatened and endangered species may be adversely affected or benefit.	"The PNW has warmed about 1.0 °C since 1900, or about 50 percent more than the global average warming over the same period. The warming rate for the PNW over the next century is projected to be in the range of 0.1-0.6 °C/decade. …modeling of future water temperatures in the Columbia and Snake rivers predicts an increase of 1 °C or greater by 2040, adding to the increases caused by the hydrosystem" (ISAB 2007). "Downscaling of multiple global climate models for the Pacific Northwest coastal zone suggests that ocean water could warm by approximately 1°C by 2050" (Miller et al. 2013).
Changing precipitation		
Changes in seasonal precipitation that vary regionally and seasonally: in general, the northern U.S. is projected to see more winter and spring precipitation; increase in the frequency and intensity of heavy and very heavy precipitation events; increasing frequency, duration, and extent of drought; summer droughts are	Increasing uncertainty in projected precipitation and/or nonstationary hydrology could alter design standards and criteria; more variable reservoir inflow, lake levels, and channel depths could impact performance of flood risk, navigation, ecosystem restoration, hydropower, recreation, and water supply	"Projected precipitation changes for the region are relatively modest … Most models project long-term increases in winter precipitation and decreases in summer precipitation. … in the Columbia Basin: • Warmer temperatures will result in more precipitation falling as rain rather than snow • Snow pack will diminish, and stream flow timing will be altered • Peak river flows will likely increase … projected changes in natural runoff, even under the most extreme warming scenarios for the late 21st

Potential Impacts*	Potential Corps Vulnerabilities/Opportunities	Regional References
expected to intensify in most regions of the U.S.; changes in snow volume and onset of snowmelt; more variable stream flow and lake levels; altered habitat suitability; changes in invasive species or pest distribution; change in magnitude and frequency of flooding and low flows; altered sediment regimes, streambank erosion, aggradation, and degradation; changes in stormwater magnitude and frequency and levels of pollutants in runoff; altered groundwater.	missions; more intense flooding over most of the US; wetland and shoreline impacts; increasing very heavy precipitation and changes in dredging requirements for rivers and harbors; changes in soil moisture could alter infiltration and impact rainfall-runoff relationships; more intense precipitation and runoff generally increase sediment, nitrogen, and pollutant loads; shifts in ecosystem structure and function may adversely impact or benefit threatened and endangered species.	century, are substantially smaller than the changes caused by the development and operation of the hydrosystem in the late 20th century" (ISAB 2007). "A consensus has not yet been reached on how the frequency and magnitude of storms may change in coastal regions of the US" (Parris et al. 2012).
Increases in extreme weather		
Increasing variability, altered seasonality, and changing intensity or frequency of heat waves, floods and droughts, depending on location; warming sea surface temperatures are projected to result in increasing tropical storm intensity for the largest storms.	Increasing uncertainty in the magnitude and frequency of extreme floods could impact life safety and alter design standards and criteria; more variable reservoir inflow and lake levels could impact performance of flood risk, navigation, ecosystem restoration, hydropower, recreation, and water supply missions; impacts to wetlands shorelines that impact the regulatory missions; increased floods, droughts, and storms impact sedimentation and shoaling, altering dredging requirements.	In the Pacific Northwest, the amount of precipitation falling in *very heavy* precipitation events (the heaviest 1 percent of all daily events) increased 16 percent from 1958 to 2007 (CEQ 2011b; Karl et al. 2009). Extreme high-sea-level events (>99.99^{th} percentile level or 1.41 m above historical mean sea level) increase under sea-level rise scenarios, but the duration of extremes differs substantially (NRC 2012, p. 104). Several observational studies have reported that high waves have been getting higher and that winds have been getting stronger in the northeastern Pacific over the past few decades" (NRC 2012, p. 82).
Sea-level change and associated tides, waves, and surges		

Potential Impacts*	Potential Corps Vulnerabilities/Opportunities	Regional References
In Alaska and the Pacific Northwest, locations experiencing glacial rebound may be impacted by falling local relative sea levels, increasing shoreline erosion, and the need for dredging. Elsewhere, rising local relative sea level will cause more frequent inundation of low-lying land; increased shoreline erosion and changes to barrier islands and inlets; increased storm waves, surges, and tides; loss of or changes to coastal wetlands; changes in estuarine structure and processes; increased saline intrusion into coastal aquifers; altered sedimentation and shoaling in channels and harbors; changes in ecosystem structure and species distributions, including invasive species and pests; altered frequency and extent of harmful algal blooms and coastal hypoxia events.	Increased need for emergency preparedness, response, and recovery for more frequent inundation; increasing uncertainty in the magnitude and frequency of storm tides and surges could alter design standards and criteria; higher average and extreme water levels could impact performance of navigation, coastal risk reduction, ecosystem restoration, and missions; changes in sedimentation and shoaling could impact dredging; decreases in harbor and port performance reliability; impacts to wetlands that affect the scope of the regulatory mission.	"Historically, most coastal damage has occurred when storm surges and large waves coincided with high astronomical tides and El Niños—a combination that can raise short-term sea level above sea levels projected for 2100. All climate models project ample winter storm activity, but a clear consensus has not yet emerged on whether storm frequency or intensity will change in the northeast Pacific" (NRC 2012, p. 82). "We have very high confidence (>9 in 10 chance) that global mean sea level will rise at least 0.2 meters (8 inches) and no more than 2.0 meters (6.6 feet) by 2100" (Parris et al. 2012, p. 10). Sea level at Astoria depends on global sea level and the effects of physical processes on uplift and subsidence of the solid earth surface: Alaskan glacier melt, glacial isostatic adjustment, groundwater withdrawal, and Cascadia Subduction Zone tectonics. Calculated corrected trend in tide gage records at Astoria is +0.30 mm/yr (95 percent CL: +0.61, -0.01) (NRC 2012, p. 66, 70, 74, 156). On the Washington Coast, the timing and magnitude of upwelling, and corresponding coastal productivity, may be influenced by changes in sea-surface temperature, though it is considered unlikely that upwelling favorable winds will considerably change by 2100. The magnitude and extent of ocean water with pH reduced relative to contemporary values is expected to increase; this water is currently drawn to the surface only during intense upwelling but exposure of shallow coastal areas to corrosive water is expected to increase by 2050, and calcifying organisms will experience reduced availability of carbonate ions. Concentrations of dissolved oxygen in coastal locations are expected to continue to decline (Miller et al. 2013).

***Note: In consideration of space, impacts and vulnerabilities identified by the Corps (2013a) that are not relevant to this EIS were not included in columns 1 and 2.**

4.5.3 Potential Climate Change Effects of Double-crested Cormorant Predation of Juvenile Salmonids

The changes to physical processes in the Columbia River Basin and Pacific Ocean expected from climate change (Table 4-6) have the potential to influence habitat condition, habitat availability, and predator-prey relationships (ISAB 2007). While there are numerous ecological implications of climate change effects throughout the basin, the following section considers the potential impacts as they relate to DCCOs and predation on juvenile salmon in the Columbia River Estuary. The ecological implications of climate change are presented at a broad level, because studies specific to the question of climate change effects on predation of juvenile salmonids by DCCOs in the region are not available at this time. The review covers evidence from the literature regarding the four areas of potential impacts identified by the Corps: increasing air temperatures, changing precipitation, increases in extreme events, and sea level change and associated ocean effects (Table 4-6). The potential effects of sea level rise, specific to DCCO nesting on East Sand Island, are further analyzed using modeling approaches in Section 4.5.3.

Effects of Discharge on Prey Availability

Climate change effects in the Columbia River Basin are expected to result in changes to river discharge, in terms of timing and magnitude of peak flow events. It is expected that flows will be higher during winter and early spring and lower during summer (ISAB 2007). In the lower Columbia River, reduced river flows allow for greater intrusion of marine water into the estuarine area (ISAB 2007). Marine and estuarine waters of the Lower Columbia River Estuary are generally considered productive, as several species of marine forage fish (anchovy, smelt, herring) occupy these waters and provide a diverse forage base (Bottom and Jones 1990). The highest proportion of juvenile salmon in the diets of DCCOs typically occurs during early May, which corresponds with a period of high river flows, high abundances of juvenile salmon, and low abundances of forage fish (Weitkamp et al. 2012, Roby et al. 2013).

Later in the season, when salmonids are less abundant and river flows decrease, the diets of DCCOs include greater proportions of other marine and freshwater taxa (Roby et al. 2013). In the Columbia River Estuary, Lyons (2010) noted that high river flows reduced saltwater intrusion into the estuary and diminished the availability of marine forage fish to Caspian terns. Several researchers have put forth the notion that river flow and intrusion of salt water into the estuary influence the diet of DCCOs in the Columbia River Estuary (Anderson et al. 2004a; Weitkamp et al. 2012; Roby et al. 2013). Similar patterns have been observed in other estuaries and by other piscivorous avian species. For example, in the Minho estuary (Southwest Europe), great cormorants (*Phalacrocorax carbo*) consumed fewer marine species and a greater proportion of freshwater species when river discharge was high (Dias et al. 2012).

Effects of Climate Change on Timing of Juvenile Salmon Migration

Given that salmon exhibit multiple life history strategies, requiring a variety of habitats and conditions throughout their life cycles (Groot and Margolis 1991), the effects of climate change will likely promulgate throughout various life stages. As reviewed by Crozier (2011), changes in climate are affecting numerous taxa in terrestrial, freshwater, and marine environments, such that the timing of various life functions (e.g. migrations) are occurring earlier and at increased rates. Given the broad scale predictions of climate changes to river discharge patterns, as well as increased water temperatures, it is plausible that changes to these important environmental cues will elicit shifts in life history patterns (ISAB 2007) and juvenile migration timing (Crozier et al. 2008) by some populations of salmon.

Environmental shifts are capable of causing trophic level shifts, such that there becomes a mismatch between the occurrences of predators and prey (Gremillet and Boulinier 2009; Tillmann and Siemann 2011). An example of this decoupling occurred in the California current during 2005, when upwelling occurred later than normal, delaying primary production and resulting in recruitment failure of rockfish, decreased survival of salmon, and nesting failure and mortality of seabirds (Peterson and Schwing 2008). Population level shifts of large magnitude can have serious consequences for the overall ecosystem (Crozier et al. 2011). In the case of changes to migration timing by juvenile salmon, if peak migration occurs before the DCCO breeding season (April), such a phenological shift may diminish the likelihood of co-occurrence with DCCOs in the Columbia River Estuary. While this could potentially have negative consequences for DCCOs, predation rates on juvenile salmon may be reduced. The converse could also be true.

Effects of Increased Water Temperature on Prey Availability

Increased water temperatures can cause prey to shift to other locations, which may constrain foraging ability for some seabirds (Thompson and Hamer 2000). Within the Columbia River Basin, locations within the Snake and Willamette Rivers already experience thermal conditions that are at the upper limits of tolerance for salmonids (Beechie et al. 2012).

It is anticipated that warmer water occurring upstream and in tributaries would likely be transported to the Columbia River Estuary (ISAB 2007). Additional temperature increases may exacerbate conditions for juvenile salmon, causing additional stress and harm (Beechie et al. 2012). For example, Petersen and Kitchell (2001) determined that juvenile salmon were more vulnerable to predation by piscivorous fish when water temperature was warmer. Hostetter et al. (2012) found that, for juvenile steelhead, a reduction in fish condition increased the likelihood of predation by DCCOs in the estuary. Increased water temperature in the Columbia

Basin has the potential to adversely affect physiological processes and increase stress in juvenile salmon. The results of warmer temperatures and higher stress in juvenile salmon may be increased predation-related mortality rates (ISAB 2007) by predators such as DCCOs.

Effects of Changes in Precipitation, Flooding, and Storms on Nesting

Changes in weather patterns, such as increased storms, flooding, and precipitation, are capable of degrading critical avian nesting and foraging habitats (Brinker et al 2007; ISAB 2007). Alterations to habitat caused by drought and flooding affect DCCOs (Adkins and Roby 2010), particularly within interior regions of the Pacific Flyway (Pacific Flyway Council 2012). In the Columbia River Estuary, increased flooding and storms may be exacerbated by ocean weather and could affect nesting success of DCCOs in the Columbia River Estuary. Relatively small amounts of nest inundation (at least 6 inches during the course of a week) may preclude nesting by DCCOs at East Sand Island (D. Lyons, personal communication). There has been a documented increase in very heavy precipitation events in the Pacific Northwest, which would increase potential for nest inundation (Table 4-6).

Influence of Climate-Driven Ocean Conditions on Prey, Adult Mortality, and Breeding

Large-scale climatic events influence physical properties within the ocean and, in turn, the ecosystem of the eastern Pacific. The biological response of such events influences many organisms, with seabirds being affected by ocean-climate conditions through changes in prey availability, which can influence survival and reproductive success (McGowan et al. 1998; Sydeman et al. 2001; Chaves et al. 2003). The strength and frequency of climatic events, such as El Niño, have been associated with high adult mortality and breeding failure among seabirds (Thompson and Hamer 2000). DCCOs are among those seabirds whose populations can be adversely affected through changes in food availability (Wilson 1991; Adkins and Roby 2010).

In the Columbia River Estuary, abundance of marine forage fish was coupled with Pacific Decadal Oscillation (Lyons 2010), suggesting a link between ocean conditions and availability of forage fish in the estuarine environment. While salmonids comprise appreciable portions in the diets of DCCOs, anchovy are the most abundant prey resource for these birds in the Columbia River Estuary (Roby et al. 2013). During periods that correspond to reductions in marine forage fish, DCCOs do not appear limited by food resources (Adkins and Roby 2010). In fact, unfavorable ocean conditions that result in reduced abundances of marine forage fish in the Columbia River Estuary may result in increased predation on juvenile salmon (ISAB 2007).

Effects of Sea Level Rise on Habitat Availability

On a broad scale, sea level rise will likely result in substantial losses of intertidal habitat, which will impose adverse impacts to shorebirds in coastal areas (Galbraith et al. 2002) as well as populations of breeding seabirds requiring low elevation estuarine habitats (Brinker et al. 2007). The Oregon Climate Change Research Institute (OCCRI 2010) acknowledges that potential loss of habitat as a result of sea level rise is of particular concern in the Columbia River Estuary, due to its important role in providing nesting and roosting areas for several avian species, including DCCOs. The combined effects of sea level rise, changes with associated tides, and increased storm and wave surges have the potential to adversely affect DCCOs in the Columbia River Estuary through breeding failure or displacement to other more hospitable areas. The potential effects of sea level rise on inundation of nesting area on East Sand Island are modeled in Section 4.5.4.

Summary

There are numerous potential effects of climate change on DCCOs nesting at East Sand Island. For example, increased storm surge and waves, combined with precipitation and inundation, can preclude DCCOs nesting in low-lying nearshore areas. Oceanic climatic events can adversely affect populations of DCCOs by diminishing the availability of food resources (Wilson 1991; McGowan et al. 1998; Adkins and Roby 2010). Shifts in the timing, strength, and location of upwelling, thermal conditions, and ocean currents can cause large-scale ecosystem responses by the food chain in the eastern Pacific (McGowan et al. 1998;, Sydeman et al. 2001; Chaves et al. 2003).

Despite the potentially detrimental effects of oceanic conditions on DCCOs and seabird species, DCCOs nesting at East Sand Island have not experienced responses akin to those in coastal areas. DCCOs appear to be more responsive to oceanic and climatic conditions at breeding areas along the coast, as well as interior areas of the Pacific Northwest (Anderson et al. 2004b). The growing population of DCCOs at East Sand Island (Anderson et al. 2004b) has been attributed to stable foraging conditions within the Columbia River Estuary. In an evaluation of oceanic and riverine conditions, Lyons (2010) was unable to link climatic factors (e.g., PDO and ENSO index, upwelling, sea surface temperature, and river discharge) and the consumption of juvenile salmon by DCCOs in the Columbia River Estuary; however, the relationship between predation and climate may have been confounded by the positive growth rate of the DCCO population. The continued growth of the DCCO colony on East Sand Island, despite declines in marine forage fish during some years, indicates food is not a limiting factor at this site (Adkins and Roby 2010).

Many of the anticipated responses of climate change predict adverse constraints to organisms (e.g. loss of habitat), yet some species may actually benefit through opportunities resulting in increased foraging potential, and others may be well suited to adapt to new conditions (Thompson and Hamer 2000). With the ability to practice generalist feeding strategies (USFWS 2009) and consume a diversity of prey types (Roby et al. 2013), DCCOs appear to be successful at adapting their feeding strategies when some prey resources become scarce. Gremillet and Boulinier (2009) suggest the foraging adaptability by cormorants to various biotic and abiotic situations makes it very difficult to predict the response of this species to climate change. Furthermore, the variability in strength and timing of climatic events poses additional challenges, especially when long-term data sets are lacking (Wilson 1991).

Understanding potential climate change impacts to avian populations and ecosystems becomes an even greater hurdle when contemplating the synergies of biotic and abiotic conditions, as well as anthropogenic influences (Thompson and Hamer 2000; Galbarith et al. 2002). For example, increased river temperatures will likely impose additional stress on juvenile salmonids, making them more susceptible to predation by DCCOs (ISAB 2007) – a positive result of climate change for DCCOs. However, other climate-driven events, such as drought in interior portions of Oregon and decreased productivity in the ocean, have been attributed to immigration by DCCOs, as individuals relocate to more favorable locations, such as East Sand Island (Anderson et al. 2004b).

The proposed terrain modification from Phase II of the action alternatives (Chapter 2) also has the potential to benefit from effects of sea-level rise, creating mudflats suitable for shorebird roosting, which will be unsuitable for DCCO nesting because of inundation. The results from models of inundation and potential land cover for terrain modification and sea level rise scenarios are discussed in section 4.5.4.

4.5.4 Modeling Climate Change-Related Effects to East Sand Island

As described in the preceding literature review, few of the climate change-related factors affecting DCCO predation on juvenile salmonids at East Sand Island are directly controlled by the Corps. Due to its proximity to the Pacific Ocean and location in the Columbia River, East Sand Island can be expected to experience many of the climate change-related effects discussed in Sections 4.5.2 and 4.5.3. Moreover, uncertainty about the potential effects of climate change on predation is high, due to the complicated relationships of physical drivers and biological responses involved in the ecological pathways of the Columbia River Estuary.

Under Phase II of each action alternative, the Corps is proposing to modify the terrain of East Sand Island. This will mean substantial changes to the topography of the island and exposure to frequent inundation from tidal events and storm surges. While the Corps does not consider East Sand Island critical infrastructure for risk planning, it is important in maintaining stability of the Federal navigation channel on the lower Columbia River.

Due to the probability of the island experiencing altered climate change effects from proposed terrain modification, a 4-step quantitative analysis was completed, specific to the terrain modification concept. The purpose of the analysis was to ascertain probable general consequences of climate change on the biological functions of the proposed modified terrain, compared to the existing condition. First, sea level rise scenarios that integrate global and local effects were developed according to Corps' regulation (USACE 2013b). Second, Corps adaptive hydraulics modeling (AdH) results corresponding to global sea level rise scenarios (Pevey et al. 2012) were interpolated for local effects of vertical change in land surface elevation at Astoria, Oregon. Third, changes to patterns of inundation under sea level rise scenarios were modeled. Fourth, the potential land cover distribution at East Sand Island under the baseline condition and sea level rise scenarios was modeled. This approach does not include hydrodynamic modeling of the potential effects of erosion associated with waves, storm surges, or movement of large wood on the long-term stability of the conceptual design for terrain modification; complete erosion analyses are anticipated as part of project engineering. Relative to the CEQ guidance regarding projects with long life spans, it is noted that the terrain modification design for East Sand Island in Phase II (see Section 2.2.3) has a 50-year design life.

Together, these four steps make it possible to consider a range of inundation and land cover changes that span the potential effects of various impacts on sea level, a scenario-based planning approach that was recommended by the National Research Council (NRC 1987, 2012) and is consistent with the climate change policy direction reviewed in Section 4.5.1.

Development of Sea Level Rise Scenarios

For this EIS, sea level rise scenarios for the proposed 50-year design life (2017-2067) of modified terrain at East Sand Island were developed with tide gage data from Astoria, Oregon using an online tool (http://globalchange.gov/what-we-do/assessment/coastal-resilience-resources). Astoria is the nearest long-term tidal record site to East Sand Island, and the net local change in relative sea level, based on 82 years from 1925 is -0.31 mm/yr (95 percent CI = 0.40) (http://tidesandcurrents.noaa.gov/sltrends/msltrendstable.htm). That is, regional land uplift has been occurring faster than global sea level rise. However, this relationship is anticipated to change as sea level rise escalates, so a recent estimate of the future trend is +0.30 mm/yr (95 percent CI = 0.31) (NRC 2012). This estimate made use of local tide gage data, corrected for atmospheric pressure and land uplift, measured with global positioning systems. The online tool developed by the Corps, FEMA, and NOAA and required by engineering regulation (Parris et al. 2012; USACE 2013b) produced seven sea level rise scenarios (Table 4-7).

TABLE 4-7. Estimated Relative Mean Sea Level Change (Expressed in Meters) Under Seven Scenarios Developed by Corps (2013b) and NOAA (Parris et al. 2012) for Astoria, Oregon, at 5-year Intervals for the Project Life 2017 – 2067.

Year*	NOAA Low	Corps Low	NOAA Int-Low	Corps Int	NOAA Int-High	Corps High	NOAA High
2017	-0.01	-0.01	0.01	0.01	0.04	0.06	0.09
2022	-0.01	-0.01	0.01	0.01	0.07	0.09	0.13
2027	-0.01	-0.01	0.02	0.02	0.09	0.12	0.18
2032	-0.02	-0.02	0.03	0.03	0.12	0.16	0.23
2037	-0.02	-0.02	0.04	0.04	0.16	0.21	0.3
2042	-0.02	-0.02	0.05	0.05	0.2	0.26	0.37
2047	-0.02	-0.02	0.06	0.06	0.24	0.32	0.45
2052	-0.02	-0.02	0.07	0.07	0.29	0.38	0.54
2057	-0.03	-0.03	0.09	0.09	0.34	0.45	0.63
2062	-0.03	-0.03	0.1	0.1	0.4	0.53	0.73
2067	**-0.03**	**-0.03**	**0.12**	**0.12**	**0.46**	**0.61**	**0.85**

*These results are relative to the 2017 baseline, and the 2067 data (50-year design) are the basis for simulations in this EIS. Results for Corps low are equivalent to NOAA low and results for Corps intermediate (Int) are equivalent to NOAA intermediate-low (Int-Low). This table was produced using online tool: http://www.corpsclimate.us/ccaceslcurves.cfm.

A low scenario of 0.0 m, an intermediate scenario of +0.12 m, and a high scenario of +0.5 m over the 50-year design life were selected from the scenarios for further modeling analysis in steps 2-4 of this procedure. At the end of the 50-year design life in year 2067, the Corps and NOAA low sea level rise scenario is for a small sea level fall (-0.03 m), very close to the base condition of 0.0 m change (Figure 4-12). The Corps' intermediate scenario (+0.12 m) is equivalent to the NOAA intermediate low scenario, "…based on the upper end of IPCC Fourth Assessment Report (AR4) global sea level rise projections resulting from climate models using the B1 emissions scenario … The intermediate low scenario allows experts and decision makers to assess risk primarily from ocean warming" (Parris et al. 2012; also see IPCC 2001, 2007a, 2007b). The NOAA intermediate high scenario (+0.46 m, conservatively rounded to +0.5 m) used as the high scenario in this EIS "…is based on an average of the high end of semi-empirical, global sea level rise projections." The intermediate-high scenario allows experts and decision makers to assess risk from limited ice sheet loss" (Parris et al. 2012). Semi-empirical projections are based on statistical relationships between observations of global sea level change. This intermediate-high scenario of +0.5 m over the 50-year design life (2017-2067) incorporates ocean warming and limited ice sheet loss, and is considered sufficient for the low level of risk associated with a terrain alteration project on an uninhabited island without critical infrastructure, for habitat management purposes.

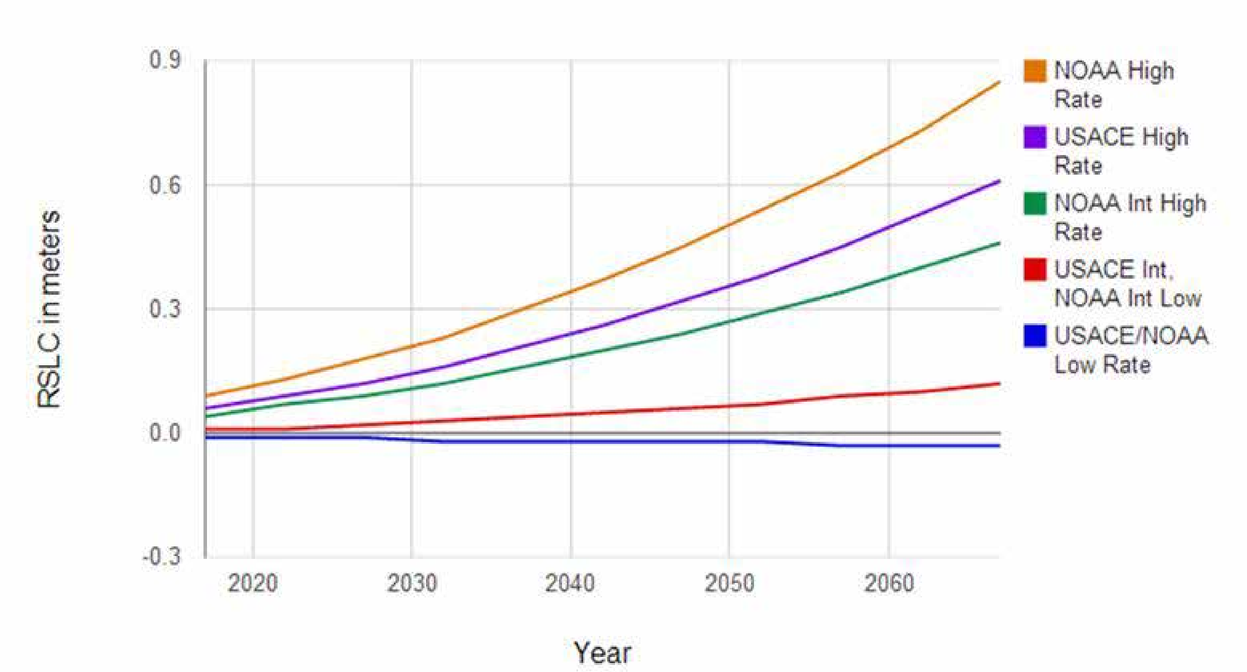


FIGURE 4-12. Relative sea level change (RSLC) scenarios for planning, 50-year design life from 2017–2067, based on analyses in Corps (2011b) and Parris (2012). The curves were calculated with an online tool associated with the Corps regulation, at: http://www.corpclimate.us/ccaceslcurves.cfm.

Water Surface Elevation Modeling of Sea Level Rise Scenarios

In accordance with guidance (USACE 2011b), the Corps modeled three sea level rise scenarios, greater than baseline conditions by 0.5, 1.0 and 1.5 m (Pevey et al. 2012). The Adaptive Hydraulics Model (AdH) (Savant and McAlpin 2014) was used with the assumption that riverbed morphology is unchanged between the three conditions (Pevey et al. 2012). The duration modeled was from March 15, 2009 to October 31, 2009. To illustrate the global sea level rise component of relative sea level rise in the estuary, a location south of East Sand Island was chosen for extracting data from model outputs, because it is not influenced by short-term water surface elevation changes caused by structures extending from the shoreline of the island (Figure 4-13).

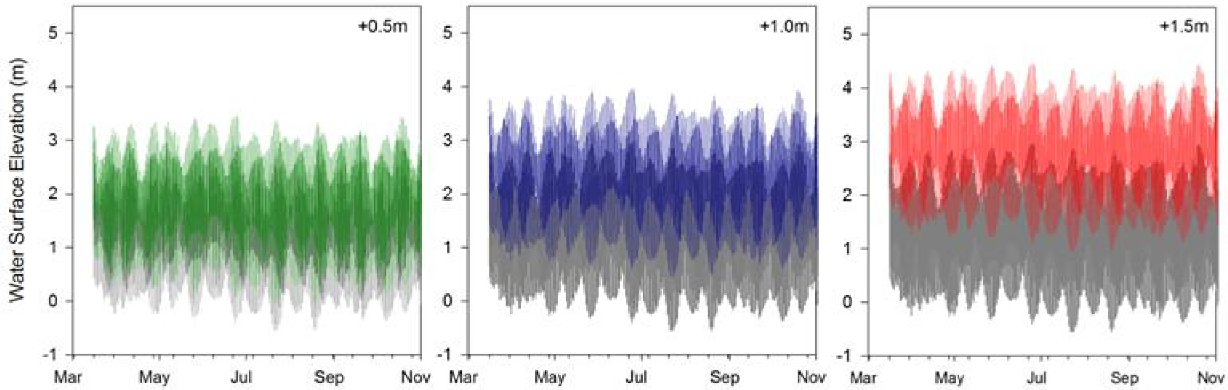


FIGURE 4-13. Water surface elevation outputs of the AdH model for March-October 2009 near East Sand Island under baseline (gray) and three global sea-level rise scenarios (+0.5, +1.0, and +1.5m). These data are uncorrected for the effects of vertical changes in local land elevation.

The mean of historical records of local sea level change is added to global sea level rise to produce scenarios for project planning. Thus, before AdH model outputs could be used as inputs for steps 3 and 4 of this analysis, they needed to be adjusted for local effects. The time series, water surface elevation data for inputs to these analyses were developed as follows: 1) the AdH model output for baseline condition (+0.0m) was used for the "low" sea level rise scenario because the estimate for Astoria is slightly negative (-0.03m sea level fall is the USACE and NOAA low scenario) and well within the uncertainty of available modeling methods; 2) for the Corps' intermediate sea level rise scenario, an estimated offset of +0.12m (equal to the NOAA intermediate-low scenario) was added to the AdH model baseline condition outputs; and 3) an offset of +0.5m was added to the AdH model baseline condition outputs to generate the high sea level rise scenario described in the preceding section.

Based on the modified AdH results, the three scenarios, +0.0 m, +0.12 m, and +0.5 m, had median water surface elevation values of 1.3 m, 1.4 m, and 1.8 m (NAVD88), respectively. In the first quartile, 25 percent of the modeled water surface elevation (WSE) observations were less than 0.67m, 0.79m, and 1.17m and for the third quartile, 25 percent of the modeled WSE observations were greater than 1.92m, 2.04m, and 2.42m for the respective three scenarios (Figure 4-14). Model results have an inherent level of uncertainty that must be considered; however, the uncertainty related to the modeled results in this analysis is fairly low. Pevey et al. (2012) present water surface elevation statistical analysis results near Astoria, Oregon (and other locations). At Astoria, Oregon the statistics of the comparisons between the AdH model results and the field data indicated either a "great" fit (variation in the elevation between 0.05 and 0.10 m) or "exceptional" fit (variation in elevation of less than 0.05 m) for all metrics, which means that over the validation period the water surface elevation differences between field observations and model estimates were less than 0.10 m.

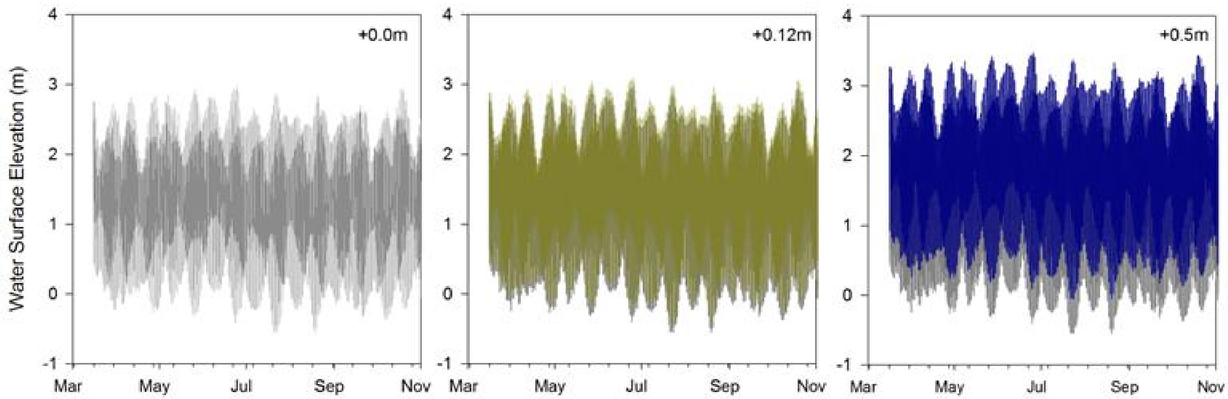


FIGURE 4-14. Water surface elevation outputs of the AdH model modified for two locally corrected 50-year sea level rise scenarios (+0.12, +0.5) near East Sand Island (2009 baseline in gray).

Inundation Modeling at East Sand Island under Sea Level Rise Scenarios

Patterns of inundation are important factors for determining habitat quality and availability for double-crested cormorants. These patterns can be measured in terms of area, timing, frequency, and duration. As noted in Section 4.6.2, inundation cycles at East Sand Island are primarily controlled by tidal cycles, and to a lesser extent, mainstem Columbia River flow and weather events. For the purpose of this assessment, inundation patterns were evaluated at East Sand Island for three sea level rise scenarios (+0.0, +0.12, and +0.5), as described in the preceding sections. Both the existing terrain and an alternative terrain design described in Chapter 2 were evaluated for potential inundation, under the same three sea level rise scenarios.

Inundation modeling was performed using an area-time inundation index model (ATIIM) (Diefenderfer et al. 2008; Johnson et al. 2011; Coleman et al. 2014). ATIIM is a GIS-based rapid site assessment tool that makes use of WSE data and high-resolution topographic data. The sources of error in the model from WSE data were described in the preceding section. The elevation accuracy for the 2009 LiDAR data is reported based on a quality control process defined in USACE (2013c), where data on open, hard, flat surfaces were assessed for consistency through the full LiDAR collection area. The results report a minimum and maximum absolute elevation accuracy range of 1 to 13 centimeters, with a root mean square error (RMSE) of 4.6 cm determined by evaluating 40,266 ground survey points. Areas with complex terrain or dense vegetation may have a degraded accuracy but spot checks on the data indicate final data are within the project required 13 cm accuracy.

The WSE inputs were provided from AdH run scenarios for three sea level rise scenarios as described in the preceding section. The topographic data used for the existing terrain condition were sourced from 2009 high-resolution LiDAR data provided by the Corps (USACE 2010) and represent an average horizontal ground spacing of 1.0 m. At the core of the model is a spatially-based wetted area algorithm that tracks an hourly time-series of inundation at 10 cm increments while maintaining hydrologic connectivity. The analysis results from ATIIM can be used to help determine trade-offs between inundation and potential habitat, contrast alternative site designs, and predict impacts of altered flow or climate regimes.

The ATIIM outputs a wide suite of metrics over a spatial and temporal continuum, taking the form of spatial data, tables, metrics, and plots. The modeling captures continuous spatial and temporal effects at hourly increments over the study period so snapshots of inundation conditions are available for any particular time of interest. For this evaluation, eight key metrics were selected. These are thought to best characterize inundation events as they affect habitat quality and availability for local avian species. The following list provides the metrics used and a description of each:

- *Cumulative Frequency of Inundation*: This metric describes how often, on the basis of percent of total possible time, a specific elevation has been inundated over the study period.
- *Inundation Exceedance Probability*: A measure to indicate the probability of occurrence (based on the historical record) for a specific elevation to be inundated. A value of 99 percent will indicate that the particular elevation is inundated often (lower elevations) and a value of 1 percent will indicate rare occurrences of inundation (high elevations).
- *Total Inundated Hectare-Hours*: The sum of the total number of hectares at a site that are inundated at each hourly time-step over the study period.
- *Total Non-Inundated Hectare-Hours*: The sum of the total number of hectares at a site that are not inundated (i.e., dry areas) at each hourly time-step over the study period.
- *Longest Duration of Non-Inundation*: The longest period of time, in hours, that a specific elevation did not get inundated with at minimum 0.2 m water depth.
- *Mean Site Inundation Depth*: The average water depth for the site at a given water surface elevation.
- *Functional Hectares Excluded*: This is a general metric to understand how water inundation will reduce the potential area of DCCO nest locations.

- *Sum Exceedance Value*: Cumulative sum of the difference between hourly water surface elevation and land surface elevation during the growing season. Used as an indicator for vegetation communities. See the following section for details.

To understand the potential impacts of climate change on East Sand Island for DCCO, the ATIIM results were extracted for elevations of potential biological significance on DCCO nesting. The significant elevations were determined by using observed point-based DCCO nesting locations from 2010-2013 and the 2009 LiDAR elevation data. The data were analyzed for the mean and the upper and lower elevation bounds of nesting to support development of meaningful metrics and relationships between nesting and patterns of inundation. While 2013 exemplifies a different DCCO management action on the island, the summary statistics describing where nesting occurs are similar to years where there were no controls and nesting occurred on the western portion of East Sand Island (Table 4-8).

TABLE 4-8. Observed DCCO Nesting Locations by Elevation from 2010-2013.

	2010	2011	2012	2013	Mean
Min	2.76	2.65	2.73	2.71	**2.7**
Mean	3.86	3.70	3.85	3.76	**3.8**
Max	4.67	5.19	4.70	4.71	**4.8**
SD	0.40	0.43	0.41	0.40	0.41

* Note that in 2013 a DCCO management action constrained the nesting area; however, the summary statistics for nesting elevations are within the normal ranges of years without management action. Sea level rise scenarios were evaluated at the means of the upper and lower bounds and mean elevation (bold values).

Despite the similar range in the summary statistics over the four years, the frequency distribution does alter from year to year as presented in Figure 4-15. Nonetheless, the following three elevations, 2.7, 3.8, and 4.8 m, (lower bound, mean elevation, and upper bound, respectively) were determined from an average over the four nesting years and subsequently used to evaluate the sea level rise scenarios for both the existing and alternative terrains.

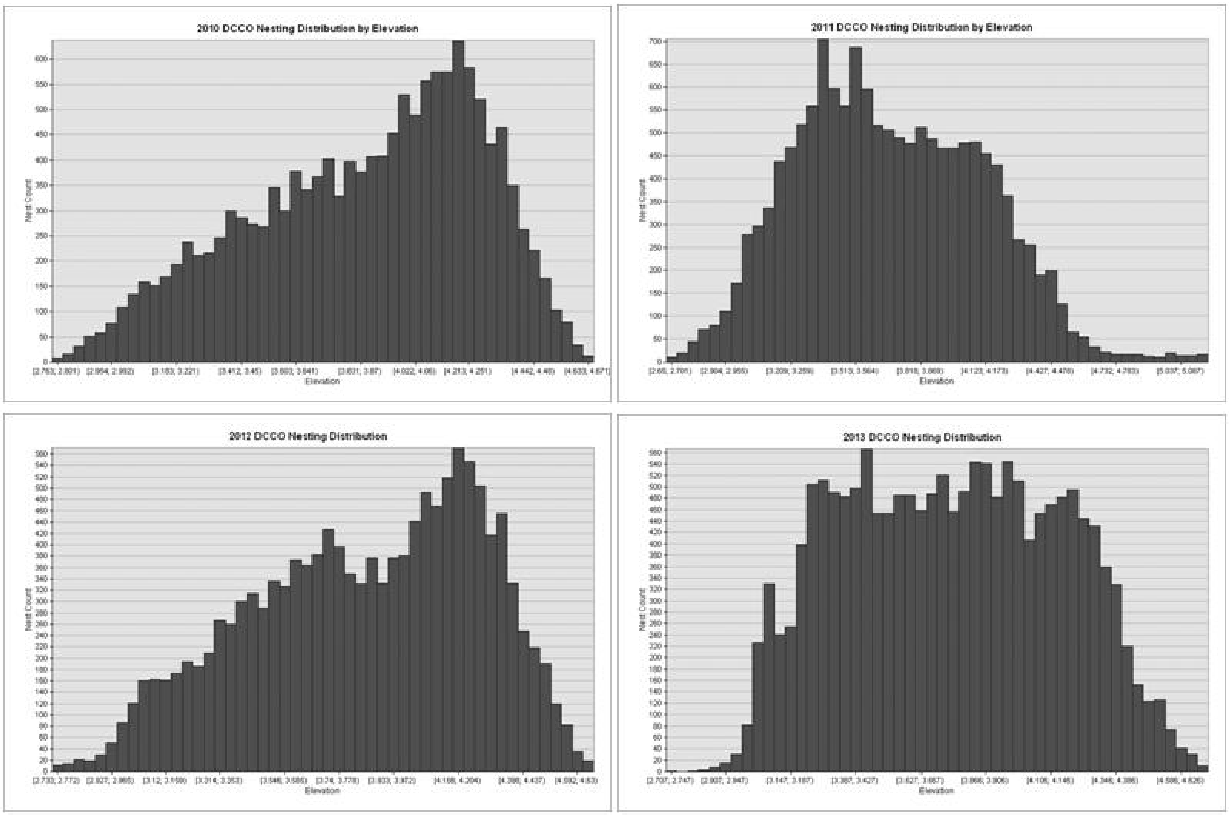


FIGURE 4-15. Frequency distribution plots of nests by NAVD88 elevation for the years 2010 (top-left), 2011 (top-right), 2012 (bottom-left), and 2013 (bottom-right).

As a simplifying assumption, the elevation range used for nesting was related to site hydraulics, such that to get an equivalent range of nesting habitat under sea level rise scenarios, the range could be shifted by the amount of sea level rise change. Hence, the sea level rise offsets were added to the original elevations derived from nesting data (2.7, 3.8, and 4.8 m) and the ATIIM metrics were evaluated for all resulting elevations. Table 4-9 presents the data for the existing and alternative terrain considering the +0.0, +0.12, and +0.5 m sea level rise scenarios for each of the elevations selected to represent low, mean, and high elevation bounds observed in DCCO nesting. It should be noted that although the nesting period of interest is April 1 – June 15, 2009, this period of record has a limited number of lunar cycles that capture the tidal extremes and range of variability; thus, we evaluated the full AdH simulation period from March 15 – October 31, 2009 to provide a more representative condition and the associated variability. There are a total of 5,544 hours in the study period; however, not all hours are considered in the metrics due to the WSE falling below the minimum land surface elevation of 0.1 m (NAVD88) (the lower extent of the LiDAR elevation data).

TABLE 4-9. Subset of ATIIM Metrics Representing Inundation-influenced Conditions on the Existing and Alternative Terrains for Three Sea Level Rise Scenarios. The bold elevation values indicate the base elevations that are representative of the low, average, and high nesting elevations.

Sea Level Rise (SLR) Scenario	Water Surface Elevation (NAVD88-m)	Cumulative Frequency of Inundation (as % of total possible)	Inundation Exceedance Probability	Total Inundated Hectare-Hours	Total Non-Inundated Hectare-Hours	Longest Duration of Non-Inundation at 0.2m Depth (Hours)	Mean Site Inundation Depth (Meters)	Functional Hectares Excluded	SEV
Existing Terrain – lower bound nesting elevation									
SLR +0.0	**2.7**	1.9	1.3	3,124	295,411	2,744	1.34	0.00	3
SLR +0.12	2.82	1.1	1.3	2,895	299,883	2,744	1.42	0.77	10
SLR +0.5	3.25	1.4	1.3	7,889	320,172	3,117	1.77	4.60	93
Existing Terrain – average nesting elevation									
SLR +0.0	**3.8**	0.0	0	0	371,571	5,544	0	0.00	0
SLR +0.12	3.9	0.0	0	0	376,439	5,544	0	0.77	0
SLR +0.5	4.35	0.0	0	0	392,932	5,544	0	4.60	0
Existing Terrain – upper bound nesting elevation									
SLR +0.0	**4.8**	0.0	0	0	400,624	5,544	0	0.00	0
SLR +0.12	4.92	0.0	0	0	401,509	5,544	0	0.77	0
SLR +0.5	5.3	0.0	0	0	403,586	5,544	0	4.60	0
Alternative Terrain – lower bound nesting elevation									
SLR +0.0	**2.7**	1.9	1.3	3,549	335,591	2,744	1.28	7.29	3
SLR +0.12	2.82	1.1	1.3	3,265	338,246	2,744	1.37	7.72	10
SLR +0.5	3.25	1.3	1.3	8,779	358,637	3,117	1.78	10.81	93
Alternative Terrain – average nesting elevation									
SLR +0.0	**3.8**	0.0	0	0	383,690	5,544	0	7.29	0
SLR +0.12	3.92	0.0	0	0	386,216	5,544	0	7.72	0
SLR +0.5	4.35	0.0	0	0	395,515	5,544	0	10.81	0
Alternative Terrain – upper bound nesting elevation									
SLR +0.0	**4.8**	0.0	0	0	400,828	5,544	0	7.29	0
SLR +0.12	4.92	0.0	0	0	401,578	5,544	0	7.72	0
SLR +0.5	5.3	0.0	0	0	403,491	5,544	0	10.81	0

The metric "Functional Acres Excluded" was evaluated with observed nesting elevations and areas in mind. The total area at East Sand Island for the elevation band between 2.7 m and 4.8 m elevation (i.e., the nesting elevation band) was used as the baseline area. The change in this area was evaluated for sea level rise removing the lower elevation bands for both the existing terrain and alternative. As the alternative terrain modifications are in the area of DCCO nesting, the change was evaluated for the whole of East Sand Island. In summary, while sea level rise alone excludes little habitat, modifying the terrain excludes approximately 17 acres, a large portion of the total area (44 acres) in that elevation band on all of East Sand Island (Table 4-10, Figure 4-16).

TABLE 4-10. Total Available Nesting Acres Available and Denied within the 2.7-4.8 m (NAVD88) Elevation Band for the Existing and Alternative Terrains Considering the Three Sea Level Rise Scenarios.

	Total Available Nesting Acres		**Nesting Acres Denied**	
Sea Level Rise	*Existing Terrain*	*Alternative Terrain*	*Existing Terrain*	*Alternative Terrain*
+0.0	45.5	27.5	0.00	18.01
+0.12	43.6	26.4	1.9	19.0
+0.5	34.1	18.8	11.36	26.7

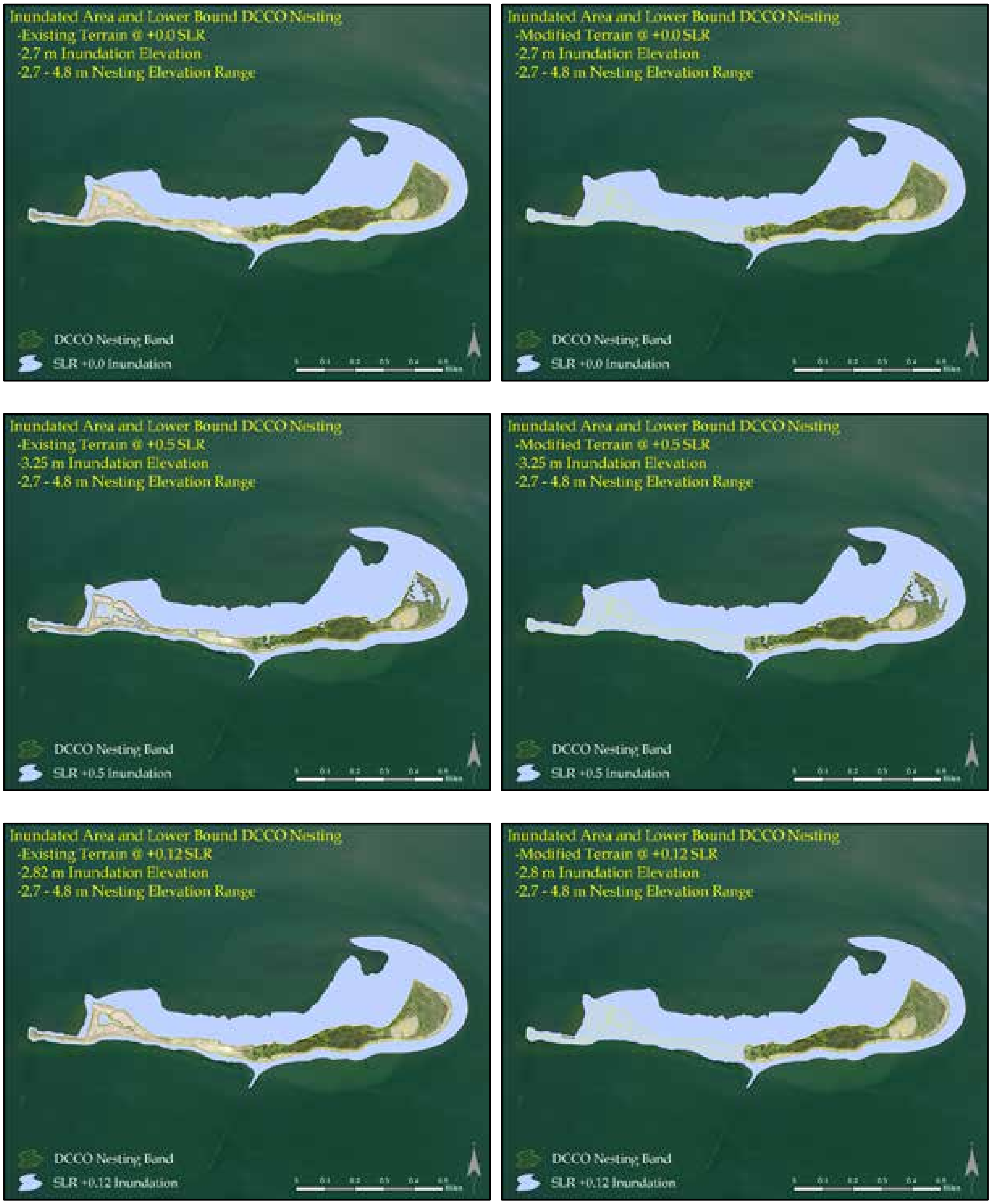


FIGURE 4-16. The inundated area and the nesting elevation range of DCCO, shown for existing and modified terrains and three sea level rise scenarios.

Land Cover Change Modeling under Sea Level Rise Scenarios

The total area of East Sand Island is 762,707 m^2 assuming a low elevation of +0.1 m (NAVD88), and the maximum elevation is 4.9 m (NAVD88). Based on reference site data in Baker Bay (Borde et al. 2011) and other observations in the region (e.g., Fox et al. 1984), in the absence of significant disturbance marshes will be expected to occur between elevations of 1.2 to 2.5 m (NAVD88), and areas above the high marsh will be expected to be colonized by dune grasses, shrubs, and trees. Field verification during wetland surveys identified typical marsh habitat occurring at slightly higher elevations than expected, approximately 2.4–3.1 m. Areas immediately below the low marsh will be expected to be intertidal mud flats extending approximately to -0.1 m (NAVD88; 0.0 m MLLW). The wetland status of areas with plant cover also depends on their soil type and hydrology, but in this region shrub-dominated and forested wetlands are typically found above high marshes (Thomas 1983; Borde et al. 2011).

To project the potential distribution of major plant communities on East Sand Island under sea level rise scenarios, we used a sum exceedance value (SEV) approach. The SEV is an index of hydrologic conditions during the vegetative growing season (Gowing and Spoor 1998), which has been modified by Borde and others (2011, 2012a, 2012b, 2013) for the lower Columbia River and estuary. The SEV as used here is a cumulative sum of the difference between hourly surface water elevation and land surface elevation during the growing season. SEVs associated with the presence of marsh vegetation and the lower boundary of woody vegetation were previously calculated from data collected at two marsh reference sites in Baker Bay by Borde et al. (2011, 2013). The main assumption associated with this method is that the inundation tolerance ranges evidenced at reference sites are suitable for the same plant communities in the future and soils are suitable. Effects of potential salinity intrusion with climate change are not expected to change wetland type because the freshwater river flows keep wetlands in the estuary brackish. The analysis does not incorporate potential effects of air temperature on growing season or evolutionary adaptation by plant species.

For the purpose of this EIS, SEVs were calculated from the AdH model outputs for the baseline condition and sea level rise scenarios across the range of land elevations at East Sand Island. The SEVs were not calculated for the low scenario (decrease of -0.03m) because the difference between this scenario and the baseline condition is smaller than the errors associated with data sources used in this analysis. All SEVs were calculated at 10 cm land elevation increments (relative to NAVD88), permitting the SEVs calculated for sea level rise scenarios to be compared on a land-elevation basis.

Using these methods, the land elevation ranges at which SEVs suitable for marsh vegetation and woody plants occurred were identified for baseline and sea level rise scenarios (Table 4-

11). According to the analysis, the current elevation ranges of plant communities will increase in response to sea level rise as expected, regardless of whether terrain is in the existing condition or modified (Figure 4-17). The elevation ranges of marsh communities predicted by SEV analysis are shown on each panel. Woody plants are expected to occur above the marshes, and mud flats are expected to extend slightly beyond the boundary of LiDAR data (white line) to -0.1m (NAVD88). With the existing condition terrain, the total area of potential wetland or upland vegetation, not including submerged aquatic vegetation, is projected to decrease as first the northern side of the island, and then the western and eastern portions are subjected to increased inundation as sea level rises. The decrease in both total area and total percentage vegetated area accelerates over the 50 years; it is approximately twice as large between the medium and high scenarios as it is between the baseline and medium scenarios. With existing condition terrain, the area of mudflat is expected to progressively increase as sea level rises. With the modified terrain, total potential marsh area is estimated to be 10-19 percent greater than existing condition under baseline and both sea level rise scenarios; total potential woody plant area is 34-36 percent less than existing condition under baseline and both sea level rise scenarios; and total area of mudflats is 10-13 percent greater under baseline and both sea level rise scenarios (Table 4-11).

TABLE 4-11. The Area of Potential Natural Vegetation Communities at East Sand Island Based on the Controlling Factor of Tidal Regime, Under Baseline and Two Sea Level Rise Scenarios.

Scenario	Min/Max Elevation of Potential Marsh Community (NAVD88-m)	Total Area of Potential Marsh Community (acres)	Total Area of Potential Woody Plant Community	Percentage of East Sand Island With Potential Marsh Community*	Total Area of Mudflats to +0.1m (acres)**
Existing Terrain/Current Condition	1.3/2.6	72	234,463 m^2	38.5%	58
Existing Terrain/Base + 0.12m (NAVD88) (medium)	1.5/2.8	65	215,944 m^2	34.3%	70
Existing Terrain/Base + 0.5m (NAVD88) (high)	1.8/3.1	50	195,138 m^2	26.6%	90
Alternative Terrain/Current Condition	1.3/2.6	86	150,851 m^2	45.8%	65
Alternative Terrain/ Base + 0.12m (NAVD88) (medium)	1.5/2.8	76	143,343 m^2	40.1%	77
Alternative Terrain/ Base + 0.5m (NAVD88) (high)	1.8/3.1	55	128,286 m^2	29.2%	102

* The total area of the island is held steady in these calculations although the exposure of its lower elevation areas to hydrologic forces is expected to greatly increase with sea level rise.

** It is only possible to calculate area of mudflat above +0.1 m (NAVD88) because of LiDAR data limitations, so all mudflat estimates are somewhat less than the actual predicted.

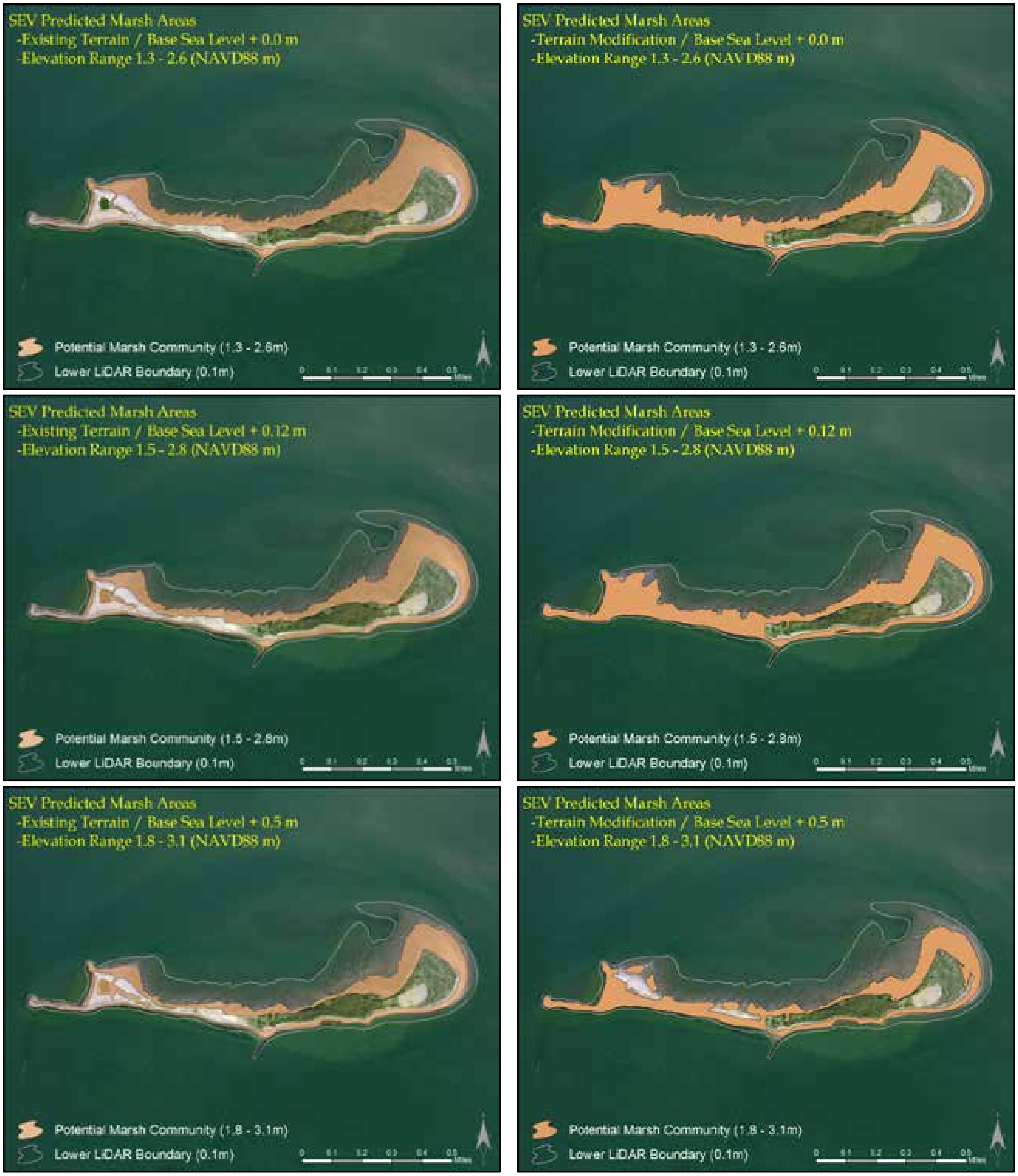


FIGURE 4-17. The potential areal extent of marsh vegetation under baseline and two sea level rise scenarios, for existing terrain (left column) and modified terrain (right column), based on the controlling factor of tidal regime.

As a validation exercise, the elevation range of marshes predicted by analysis of the AdH model outputs for baseline condition, 1.3 to 2.6 m (NAVD88), was compared to that based on water surface elevation and vegetation data collected at reference sites, 1.2 to 2.5 m (NAVD88). Many sources of error could contribute to a difference of 0.1 m and it is within the range of error of the ATIIM model, field data collection, and LiDAR data.

Field work conducted in February 2014 to delineate wetlands on the island indicates that some differences from reference site conditions exist (Appendix J). Notably, in existing condition the site supports two general types of wetland areas: 1) those associated with the sandy, well-drained soils found along the tidally influenced, exterior portions of the island ranging from elevations of approximately 2.4 to 3.4 m (NAVD88) with species composition limited to a few forbs and grass species; and 2) perched, isolated wetlands at higher elevations where a clay layer limits drainage (see Chapter 3 for details). There is very little or no emergent marsh vegetation where predicted, i.e., between the elevations of 1.2 m and 2.4 m (NAVD88) on East Sand Island. Small patches of emergent marsh vegetation occurred along the shore in a narrow elevation range that is estimated to be from approximately 2.4 to 3.0 m (NAVD88), based on the elevations derived from the LiDAR used during the wetland delineation. The likely reasons there is little marsh vegetation between 1.2m and 2.4m include: 1) the sandy sediments, 2) the currents precluding the deposition of fines, and 3) the presence of large wood continually disturbing the vegetation in this elevation range.

American dunegrass (*Leymus mollis*) and European dunegrass (*Ammophila arenaria*) were observed on the island and are likely colonizing the sandy, well drained soils in the upper elevation ranges of predicted marsh at approximately 3.0 to 3.4 m (NAVD88), with some observations of occurrence up to 6.0 m (NAVD88). Limited wetland reference site data exists for these grasses in the Lower Columbia River Estuary; however, observations at Trestle Bay indicate it occurs at least from approximately 2.4 to 2.8 m (NAVD88) (Borde et al. 2011) and likely higher given the limited elevation range of the reference site. Wetland vegetation (primarily shrubs with some herbaceous freshwater wetland vegetation such as *Carex obnupta*) was also noted at some of the higher elevations of the site (5.5 – 6.1 m [NAVD88]) where clay soils may be acting to “perch” freshwater creating wetland areas that are not directly connected to the tidal hydrology of the site.

Over time, tidally-influenced wetlands are predicted to develop in the modified terrain; however, the sandy soils in the location of the excavated areas may preclude the development of wetland vegetation in these areas at elevation of 1.2 to 2.4 m (NAVD88) because of their drainage characteristics. The future deposition of fine sediments may increase the occurrence of emergent marsh species within these elevations, but the time period necessary for this to occur is unknown. The factors affecting it include the type of vegetation in the area (e.g., dune grasses have the potential to act as a controlling factor on sand stabilization and accretion), and physical disturbance (e.g., the alternative terrain design provides rip-rap barriers on the north and south sides of the potential marsh areas, which may deflect energy and could accelerate fine-sediment deposition and accumulation).

Additional controlling factors on vegetation establishment should be considered in alternative habitat designs and climate change analysis. These include the potential effects of physical and biological disturbance on marsh development at East Sand Island. Many disturbance processes related to vegetation establishment are active at East Sand Island, including biological factors associated with the diverse avian community and physical factors (e.g., wind waves, swells, and storm surges) associated with the position of the island near the mouth of the Columbia River. Marshes do not naturally occur in areas with high wave action and East Sand Island is exposed to a long fetch in the southwesterly direction toward the river mouth. Wave analysis conducted by the Corps for the south jetty at the mouth of the Columbia River concluded that the medium sea level rise scenario could increase wave run-up elevation by 0.2 m to 0.4 m and the highest expected sea level rise scenario could increase it by 0.7 m to 1.6 m (compared to no sea level rise) (USACE 2013d).

4.5.5 Summary

This section reviewed recent developments in national guidance on climate change adaptation and related Corps' policies. Nationally, the Corps has identified four areas of potential impacts to mission and operations: 1) increasing air temperatures, 2) changing precipitation, 3) increases in extreme events, and 4) sea level change and associated tides, waves, and surges. On this basis, the potential effects of both inland hydrology and sea level rise on DCCO predation of juvenile salmon were qualitatively assessed through a literature review. There is not yet a consensus on likely changes in the frequency and magnitude of storms in the eastern Pacific (NRC 2012), so such potential hydrological effects on cormorants and predation could only be qualitatively considered. In general, the review identified high uncertainty about the ultimate effects of changes on predation because of complex ecological relationships involving physical processes and biota. Uncertainties regarding the potential effects of extreme events were outside the scope of this analysis and will be part of the engineering design phase.

The Corps has proposed a terrain modification in Phase II that will be affected by climate change. For coastal project planning, Corps' policies focus particularly on scenario-based planning for sea level rise; similarly, specific guidance has not yet been developed for expected Columbia River Basin-scale hydrological changes. Therefore, the potential impacts of sea level rise on physical processes and biological relationships were quantitatively assessed through a four-step procedure: 1) development of sea-level rise scenarios, 2) water surface elevation modeling (using AdH model), 3) inundation modeling (using ATIIM), and 4) land-cover change modeling (using a Sum Exceedance Value method).

The potential consequences of climate change on the biological functions of existing and modified terrains were compared through this 4-step procedure. In accordance with national policy, approved methods for estimating the combined effects of global sea level rise and local conditions using historical tide gage records (Parris et al. 2012; NRC 2012; USACE 2013b) were followed. The future conditions were forecast through the 50-year design life, 2017-2067, for the existing condition and the modified terrain alternative. Multiple baselines were used for sea level rise, following the guidance for scenario-based planning for climate change (NRC 1987; NRC 2012; Parris et al. 2012; USACE 2013a; CEQ 2013b). Potential effects of sea level rise on inundation and land cover change at East Sand Island were estimated using the best available models based on data previously collected in the Columbia River Estuary (Borde et al. 2011; Coleman et al. 2014). Where available, associated uncertainty estimates are given in association with the data and models used.

In summary, as sea level rises, it is expected that lower elevation portions of the island will be reworked and converted to mud flats suitable for shorebird roosting that will be unsuitable for DCCO nesting because of frequent inundation. The terrain modification has the potential to accommodate the effects of sea-level rise by creating a larger area of such mudflats. The modified terrain exposes a greater proportion of the surface of the island to disturbance from tides and storm surges, thus reducing the potential for DCCO nesting. The ability to create tidal wetlands to indirectly support juvenile salmon through the production and export of macrodetritis and prey is possible, but less certain because of potential physical and biological disturbances not modeled herein, as well as the requirement for adequate sediment conditions. The potential accumulation of large woody debris cannot be predicted at this time. The results of analyses in this chapter indicate that a land cover matrix including both mud flats and vegetated areas—possibly including marshes, dune grasses, and woody plants at higher elevations—could persist on East Sand Island despite sea level rise for five decades.

4.6 Other Disclosures

4.6.1 Unavoidable Adverse Effects

NEPA requires disclosure of "…any adverse environmental effects which cannot be avoided should the proposal be implemented…"(40 CFR 1502.16). Beneficial and adverse effects on the human environment that might result from the implementation of alternatives carried forward for detailed study in this EIS are analyzed earlier in this Chapter in Section 4.2.1.

Several adverse effects of varying degrees to non-target species were identified during the analysis of environmental consequences for each of the alternatives, including the no action alternative. Certain measures to minimize adverse effects have been identified, and where appropriate, have been included as part of the detailed description for each action alternative or identified as BMPs. Under alternatives that consider lethal methods, loss of individuals, nests, eggs, chicks, and fledglings are unavoidable adverse effects.

4.6.2 Energy Requirements

For environmental impact statements, NEPA requires a discussion of "[e]nergy requirements and conservation potential of various alternatives and mitigation measures" (40 CFR 1502.16(e)). The alternatives under consideration require consumption of energy in the form of fuel for boat-based transportation to East Sand Island (and other locations in the Columbia River Estuary or coastal Oregon and Washington for monitoring and hazing) and fuel for planes for aerial surveys. All the action alternatives require a similar level of effort for accessing East Sand Island. Alternatives B and D which promote re-distribution of >7,500 breeding pairs could require substantially more energy in the form of fuel for boat-based and aerial surveys throughout the 172 mile long Columbia River Estuary. There is some conservation potential in utilizing more fuel efficient boats and this would be considered in the implementation. Additional conservation potential (respective of energy requirements) could be in the potential to use drones to conduct the aerial surveys and the Corps is currently reviewing opportunities to do this.

4.6.3 Irreversible and Irretrievable Commitment of Resources

For environmental impact statements, NEPA requires a discussion of "…any irreversible or irretrievable commitments of resources which would be involved in the proposal should it be implemented…"(40 CFR 1502.16). For NEPA purposes an irreversible or irretrievable commitment of resources refers to impacts on or losses to resources that cannot be recovered or reversed. Examples include permanent conversion of wetlands or permanent loss of wildlife or other biological resources, etc. Habitat and wetlands altered from the proposed habitat modification could be restored to their initial state with additional terrain modification. Potential loss of cultural resources from the proposed actions is addressed in Chapter 4.
This EIS analyzes impacts from alternatives that propose lethal take of DCCOs and eggs from the western population. This may be considered an irreversible and irretrievable commitment of a biological resource; however, it is not expected that permanent loss of the population would occur or recovery potential to be permanently affected. These effects are analyzed earlier in this Chapter under Section 4.2.1.

4.6.4 Incomplete and Unavailable Information

CEQ NEPA regulation at 40 CFR 1502.22 (incomplete or unavailable information) requires an agency, when evaluating reasonably foreseeable significant adverse effects of a proposed action, to obtain, if possible, incomplete or unavailable information or disclose why such information is not attainable and provide a discussion of why the information is relevant and a summary of the best available existing scientific evidence used to predict the impacts.

One area of uncertainty related to this EIS relevant to the decision-making process is exact dispersal patterns of DCCOs as result of intensified management actions. While some information regarding possible dispersal locations has been obtained, it is impossible to predict exact locations DCCOs would relocate to and what specific effects, if any, there might be from their relocation. For several years, the Corps has attempted to obtain this information with banding DCCOs, placing radio and satellite tags on adult DCCOs and monitoring them, and conducting aerial surveys.

Although the sample sizes were limited during these monitoring efforts, there has been consistency in DCCO use areas, both during and after the nesting season. These regions are summarized throughout this document and addressed in the affected environment section. To obtain this information more precisely would be cost prohibitive as telemetry data can cost several thousand dollars per tracked bird. Reasonable estimates of impacts from DCCOs dispersing from East Sand Island to areas of the affected environment were made based on past research, likelihood of colonies to establish given habitat, food availability, and lack of predators or human disturbance, and in coordination with the states of Oregon and Washington. To compensate for this uncertainty, all of the action alternatives include some monitoring to detect abundance of DCCOs in the estuary and abundance of DCCOs in coastal areas. Any information regarding effects of DCCO dispersal that is incomplete or unavailable at this time is therefore not essential to making a reasoned choice among alternatives.

4.6.5 Uncertainty and Compensatory Mortality

In all modeling exercising, uncertainty exists in extrapolating results from past observed data to predict or estimate future conditions. Modeling or analyses that contain more input parameters or have less direct information inherently have more associated uncertainty. To the extent possible, assumptions made in modeling exercising have been disclosed in the EIS with justification as to why particular assumptions were made or particular approaches taken.

The issue of compensatory mortality was raised during the scoping comments and has been raised by other agencies during the development of the EIS. Generally speaking, compensatory mortality is one type of mortality largely replacing, or "compensating" for another kind of mortality, but the total mortality rate of the population remains constant. This is in contrast to additive mortality, meaning one source of mortality is added to another for a combined total effect. At some point all populations have a threshold at which sources of mortality are no longer compensatory and become additive. Relevant to the EIS is the degree to which juvenile salmonid mortality by DCCOs is compensatory (i.e., reduced juvenile salmonid mortality from DCCOs is replaced by another source of mortality).

Recent research (Hostetter et al. 2012) and NOAA Fisheries' alternative barge studies indicate DCCO predation of juvenile salmonids is neither completely additive nor completely compensatory. The Hostetter et al. (2012) study utilized PIT tag recoveries of Snake River steelhead on a DCCO colony in the Columbia Plateau. Results indicated that fish in poor condition (i.e., diseased, injured, or otherwise compromised) were more susceptible to DCCO predation than apparently healthy smolts. Fish in poor condition would likely be more vulnerable to other sources of mortality, such as predation from other species, or passage through the dams. If DCCO predation were decreased, these fish would still have a high probability of dying from other mortality factors, which would likely compensate for a reduction in DCCO predation.

NOAA Fisheries' alternative barge study utilized paired groups of PIT-tagged steelhead and yearling Chinook smolts that were barged downstream and released in two locations: (1) downstream of Bonneville Dam, the location of current release site, and (2) downstream of Astoria, Oregon at night and on an outgoing tide to reduce avian predation impacts (Marsh et al. 2011). Groups that experienced lower avian predation rates in the estuary, however, returned as adults at higher rates only some of the time (Marsh et al. 2011). The differences in rates of smolt mortality produced by reducing exposure of some groups to avian predators in the estuary were compensated for by other mortality factors at quite variable rates, casting additional doubt on assumptions that avian predation in the estuary is either fully additive or fully compensatory (Lyons et al. 2014).

The NOAA Fisheries' 2014 Supplemental FCRPS Biological Opinion does not apply compensatory mortality to any of the RPA measures, including avian predation management (NOAA 2014). The analysis in this EIS also does not apply compensatory mortality to any expected benefits (economic or juvenile survival) associated with reduced DCCO predation. This is in part because the degree to which avian predation of juvenile salmonids in the Columbia River Basin is compensatory versus additive is currently unknown (Lyons et al. 2014). Additionally, the purpose and need of this EIS is to reduce depredation damage caused by DCCO predation of juvenile salmonids, which is a well-studied and documented source of mortality. Constraining management due to unknown and speculative amounts of compensatory mortality would allow a known source of significant mortality of juvenile salmonids within the Columbia River Estuary to continue unaltered. Effects analyses for fish species were limited to juvenile salmonids for these reasons. Economic effect analyses include adult fish returns and associated parameters because these are mandatory necessities to describe economic benefits. As stated in the beginning of this section, such analysis inherently contains more associated uncertainty compared to analyses limited to juvenile salmonid life stages.

4.6.6 Human Dimensions

This EIS proposes alternatives to manage the largest colony of DCCOs in North America. The concept of wildlife management is fundamentally a human one that traditionally focused on managing wildlife and their habitats to attain game management or conservation goals. Success in this approach has led to some species becoming abundant or even overly abundant. As the needs or goals of humans conflict with the needs of wildlife there has been an increasing "human dimension" to wildlife management (Decker et al. 2001). This "human dimension" is driven by the way humans perceive, interact, or have conflict with wildlife over shared resources and is largely affected by an individual's ethics and values.

Individual perceptions of the ethics of wildlife damage management and the appropriateness of specific management actions will depend on the value system of the individual. Values tend to be influenced primarily by socioeconomic status, age, gender, and experience or dependence on natural resources for cultural practice or subsistence (Kuentzel et al. 2012). Values of wildlife are generally oriented by one of two cultural ideologies: utilitarianism, which promotes beneficial "use" of wildlife (i.e., subsistence or economics) and egalitarianism, which promotes "non-use" and considers the inherent or aesthetic value of wildlife (Manfredo et al. 2008). An individual may value wildlife in more complex ways and not necessarily be restricted to any one set of values.

The differences in values held by various stakeholders interested in the Corps' DCCO management plan were identified to some degree in the scoping comments we received. Many fisheries groups expressed concern that too much time has passed, the problem will only continue to worsen compromising all the other recovery efforts, and that loss of personal income due to reduced fishing opportunities because of DCCO predation was unacceptable. Many wildlife groups commented that DCCOs were being made scapegoats and suggested we look at the true causes endangering salmon and steelhead runs, which were stated as overfishing, too many hatchery fish being released that compete with wild fish, and barriers to habitat from the continued operation of the dams.

While there are some extremes in viewpoints, many comments we received suggested we seek a balanced approach in addressing the competing needs and recommended potential solutions, some of which have been integrated into the proposed alternatives and some of which were not due to concerns over their feasibility in meeting the purpose and need (Section 2.3). The range of concerns expressed in public comments indicates there may be differences in the way impacts are perceived.

Some relevant social acceptability research has been done recently on the topic of DCCO management. Research suggests that support for DCCO management is influenced by attitude and values, beliefs about the impacts and species, and the context of the disturbance (Kuentzel et al. 2012; Bruskotter et al. 2009; Whittaker et al. 2006). Recently DCCO social acceptability research regarding fishery impacts was completed in Lake Champlain. Boaters, anglers, individuals from environmental non-profits, and homeowners on the lake were surveyed to determine attitude strengths (degree of one's feelings) about DCCOs, knowledge of DCCOs and their impacts to the fisheries, and to determine and predict support for DCCO management programs (Kuentzel et al. 2012). The survey results indicated that attitudes about DCCOs informed knowledge and beliefs. When attitudes were negative about DCCOs, respondents tended to exaggerate their knowledge on the topic of DCCO impacts to fisheries or property and were more supportive of management (Kuentzel et al. 2012). When attitudes were positive, respondents had more accurate knowledge of DCCO biology and were less concerned with DCCO impacts to the fishery and less supportive of management. Kuentzel et al. (2012) also found that approximately 21 percent of people expressed opposition to DCCO population controls, 24 percent were strongly supportive, and 53 percent were rather ambivalent. Individuals surveyed had some relative concern or connection with DCCO management or Lake Champlain, and a completely randomized sample of people could show higher levels of ambivalence toward DCCO management. Thus, the most vocal proponents on either side of DCCO management likely do not represent the vast majority of the public.

Both DCCOs and salmonids are natural components of the ecosystem and are protected under federal laws. Individuals that have an interest in the outcome of this plan do not all share common values, nor will any one management action or alternative appease all stakeholders. Thus the issues presented in this EIS pose a complex problem and importance and relevance of the "human dimension" in this EIS and management plan cannot be overstated.

4.7 Comparison of Alternatives and Summary of Environmental Consequences

TABLE 4-12. Summary of Environmental Consequences from Proposed Alternatives.

Affected Resource	No Action	Alternative B	Alternative C *(Preferred Alternative/ Management Plan)*	Alternative D
Vegetation and Soils on East Sand Island	Vegetation and soils over the 16 acres of the DCCO colony would continue to be impacted by guano. If colony increases potential for more vegetation to be impacted.	Phase I: Vegetation and soils could experience passive restoration if DCCO colony were reduced. Phase II: conversion of current bare sand to tidal mudflat or marsh areas could increase diversity of vegetation and soil complexity.	Same as Alternative B.	Same as Alternative B.
Western Population of DCCOs	Remain similar to current estimate (31,200 breeding individuals) in the near term; continue to grow at current rates; approximately 40 percent (13,000/31,200) of breeding population at East Sand Island colony.	Remain similar to current estimate (31,200 breeding individuals) in the near term; future growth potentially reduced; approximately 18 percent (5,600/31,200) of breeding population at East Sand Island.	Abundance reduced to approximately 23,250 breeding individuals (5,000 breeding individuals greater than ca. 1990 level); future growth potentially reduced; approximately 24 percent (5,600/23,250) of breeding population at East Sand Island.	Phase I: Same as Alternative C. Phase II: Future growth potentially reduced until DCCOs dispersed from East Sand Island redistribute and successfully breed at new sites; 0 percent of breeding population at East Sand Island.
Other Birds on ESI	Abundance would remain similar to current estimates; spatial distribution of nesting species would remain similar; California brown pelican distribution more uniform with decrease in management activities.	Phase I: High potential for DCCO use and hazing outside designated nesting area throughout breeding season; potential for take from hazing activities; high potential to significantly reduce abundance or exclude nesting of Brandt's cormorants; moderate to high potential to significantly reduce colony size of other nesting species (gulls and terns); low to moderate potential to reduce abundance of brown pelicans or for species to abandon East Sand Island. Phase II: High potential for DCCO use and hazing on east side of island for both the short- and long-term; high potential to significantly reduce abundance or exclude nesting of	Phase I: Low potential for overall DCCO use and hazing outside of designated nesting area; potential for take from hazing activities; potential for take of up to 0.2 percent (4-year strategy) to 0.4 percent (adjusted 2-year strategy) of Brandt's cormorant regional population per year; moderate potential to significantly reduce colony size of Brandt's cormorants; low potential to exclude Brandt's cormorant from nesting; low to moderate potential to significantly reduce colony size of other nesting species; low potential to reduce abundance of brown pelicans or for species to abandon East Sand Island. Phase II: Same as Alternative B.	Phase I: Same as Alternative C. Phase II: High levels of hazing throughout island to exclude DCCOs in short-term but low thereafter; high potential to exclude nesting of Brandt's cormorants and reduce abundance or exclude other species.

Affected Resource	**No Action**	**Alternative B**	**Alternative C *(Preferred Alternative/ Management Plan)***	**Alternative D**
		Brandt's cormorants; moderate to high potential to significantly reduce colony size of other nesting species; low to moderate potential to reduce abundance of brown pelicans or for species to abandon East Sand Island.		
Other Birds in Region	Abundance and distribution of other bird species would likely remain similar to current conditions in the near-term.	Phase I: High potential for DCCO dispersal; high potential for adverse effects to streaked horned larks from dispersal and DCCO hazing in estuary; potential for take from hazing activities; effects to other birds commensurate with dispersal levels to new areas and subsequent site-specific interactions. Phase II: Similar to Phase I; effects commensurate with dispersal levels.	Phase I: Low potential for DCCO dispersal; low potential for adverse effects to streaked horned larks from dispersal and subsequent DCCO hazing; potential for take from hazing activities; potential for take of up to 0.05 percent (4-year strategy) to 0.1 percent (adjusted 2-year strategy) of pelagic cormorant regional population per year; effects to other birds commensurate with dispersal levels to new areas and subsequent site-specific interactions. Phase II: Similar to Phase II of Alternative B. Low potential for DCCO dispersal in short-term but could increase with time.	Phase I: Same as alternative C. Phase II: High potential for DCCO dispersal in short-term and for on-going hazing in estuary (effects similar to Phase I of Alternative B in short-term); no effects once all DCCOs redistributed outside the estuary.
Lower Columbia River Basin ESA-listed Fish	Double-crested cormorant predation remain similar to current estimates in the near-term; >11 million juvenile salmonids consumed annually on average, exceeding 20 million in some years.	Phase I and II: Average annual juvenile salmonid survival increases of 1 to 4 percent (depending on group); likely to not fully realize juvenile salmonid survival benefits in the short term because hazing is not expected to be 100 percent successful in keeping DCCO out of estuary.	Phase I: Same as alternative B, but expectation is to fully realize juvenile salmonid survival benefits in the short term. Phase II: Same as alternative B Phase I in the short-term but benefits could decrease with time.	Phase I: Same as alternative C Phase II: Average annual juvenile salmonid survival increases of 2 to 8 percent (depending on ESU/DPS); but may not realize these benefits in the short-term (similar to Alternative B).

Affected Resource	No Action	Alternative B	Alternative C *(Preferred Alternative/ Management Plan)*	Alternative D
Other ESA-listed Fish in Region	Double-crested cormorant predation would remain similar to current estimates in the near-term.	Phase I: High potential for DCCO dispersal; effects to ESA-listed fish commensurate with dispersal levels to new areas and subsequent site-specific interactions; potential effects would be greatest to salmonid species in freshwater and estuary habitats that occur within the foraging range of DCCO breeding colonies or high use areas within the sub-regions of the affected environment, particularly the Washington coast and Salish Sea. Potential impacts to Pacific eulachon are expected to be minimal because of little temporal overlap between spawning and DCCO nesting. Impacts to rockfish species are also expected to be minimal because of their large size at reproduction and use of deep water, although some impacts to juveniles and larvae could occur. Phase II: Similar to Phase I; effects commensurate with dispersal levels.	Phase I: Low potential for DCCO dispersal; effects to ESA-listed fish commensurate with dispersal levels to new areas and subsequent site-specific interactions. Phase II: Similar to Phase II of Alternative B. Low potential for DCCO dispersal in short-term but could increase with time.	Phase I: Same as Alternative C. Phase II: High potential for DCCO dispersal in short-term (effects similar to Phase I of Alternative B in short-term); no effects once all DCCOs redistributed outside the estuary.
Fisheries	Annual economic value of in-river Columbia River fisheries would likely remain similar to baseline in the near-term; annual direct financial value of $41.0 M (tribal commercial [4.1 M], non-Indian commercial [4.3 M]), and freshwater sport recreational [32.5 M]); annual regional economic impact of $48.4 M (tribal commercial [7.8 M], non-Indian commercial [7.4 M]), and	Phase I and II: Annual direct financial value increases of 3.6 percent ($1.5 M) for tribal commercial (2.2 percent [$0.1 M]), non-Indian commercial (2.0 percent [$0.1 M]), and freshwater sport recreational (4.0 percent [$1.3 M]); annual regional economic impact increases of 3.1 percent ($1.5 M) for tribal commercial (2.4 percent [$0.2 M]), non-Indian commercial (1.9 percent [$0.1 M]), and freshwater sport recreational (3.5 percent [$1.2 M]);	Phase I and II: Same as Alternative B, but expectation is to fully realize benefits in the short-term.	Phase I: Same as Alternative C. Phase II: Annual direct financial value increases of 6.5 percent ($2.7 M) for tribal commercial (3.8 percent [$0.2 M]), non-Indian commercial (3.5 percent [$0.1 M]), and freshwater sport recreational (7.2 percent [$2.3 M]); annual regional economic impact increases of 5.5 percent ($2.7 M) for tribal commercial (4.3 percent [$0.3 M]),

Affected Resource	**No Action**	**Alternative B**	**Alternative C *(Preferred Alternative/ Management Plan)***	**Alternative D**
	freshwater sport recreational [33.2 M]). Predation by the DCCO colony on East Sand Island would likely continue to result in annual loss of 3.8 percent ($0.2 million) direct financial value and 4.3 percent ($0.3 million) regional economic impact to tribal fisheries; annual loss of 7.2 percent ($2.3 million) direct financial value and 6.3 percent ($2.1 million) regional economic impact to freshwater sport recreational fisheries; annual loss of 3.5 percent ($0.1 million) direct financial value and 3.5 percent ($0.3 million) regional economic impact to non-Indian commercial fisheries.	economic benefits would not be fully realized until DCCOs above the target size permanently emigrate away from the estuary.		non-Indian commercial (3.5 percent [$0.3 M]), and freshwater sport recreational (6.3 percent [$2.1 M]); economic benefits would not be fully realized until all DCCOs permanently emigrate away from the estuary.
Public Resources	Direct or indirect adverse effects to public resources (public health and human safety, transportation facilities, dams and hatcheries) would be similar to past conditions before dissuasion research.	Phase I: High potential for DCCO dispersal; high persistent DCCO use of the Astoria-Megler Bridge throughout the breeding season expected and high potential for adverse effects from DCCO guano corrosion. Effects to other transportation structures and dams and hatcheries commensurate with dispersal levels to new areas. No adverse effects to human health and safety. With high nesting concentration on East Sand Island and high levels of dispersal, potential for disease transmission among DCCOs to be higher than prior levels, but adverse effects from disease to humans or other wildlife species not documented or	Phase I: Low potential for DCCO dispersal; short-term DCCO use of the Astoria-Megler Bridge during the primary time period of lethal take during Phase I could occur, but persistent use throughout the breeding season or adverse effects not expected; effects to other transportation structures and dams and hatcheries commensurate with dispersal levels to new areas but assumed to be low. Risk to human safety from culling activities is low. Adverse effects from disease similar to Alternative B. Phase II: Similar to Phase II of	Phase I: Same as Alternative C. Phase II: High potential for DCCO dispersal in short-term (effects similar to Phase I of Alternative B in short-term); no effects once all DCCOs redistributed outside the estuary.

Affected Resource	No Action	Alternative B	Alternative C *(Preferred Alternative/ Management Plan)*	Alternative D
		low. Phase II: Similar to Phase I; effects commensurate with dispersal levels.	Alternative B. Low potential for DCCO dispersal in short-term but could increase with time.	
Historic Properties	No effect to historic properties.	Phase I: No effect to historic properties on East Sand Island from ground disturbing activities. Phase II: Terrain modification on East Sand Island could adversely affect basalt rock armor because of removal of some rock and the World War II observation tower because of increased tidal inundation. No adverse effects off of East Sand Island expected.	Same as Alternative B.	Same as Alternative B.

Chapter 5 Preferred Management Plan

As identified and described in Chapter 2, Alternative C is the Corps' preferred alternative and management plan. After evaluating the environmental consequences of each alternative when compared to the technical and logistical feasibility of reducing predation impacts throughout the Columbia River Estuary, Alternative C best meets the Corps' statutory mission and responsibilities under the Endangered Species Act as identified by the 2014 FCRPS Supplemental Biological Opinion.

Because Alternative C proposes a reduction in colony size abundance through culling, there is more certainty this alternative would meet the need of reducing double-crested cormorant predation throughout the Columbia River Estuary than Alternatives B and D, which propose abundance reduction through dispersal. Minimal DCCO dispersal is expected under Alternative C given proposed field techniques and knowledge from other similar programs. This alternative has the greatest certainty of having least direct and indirect adverse effects to non-target species and resources off East Sand Island, particularly streaked horned larks, which would likely be adversely affected by high levels of double-crested cormorant dispersal and associated hazing activities within the Columbia River Estuary.

Alternative C has the lowest associated dollar costs for implementation and, given the breadth of the Columbia River Estuary, the greatest certainty that indefinite commitment of resources would not be needed to achieve the level of predation reduction specified in Reasonable and Prudent Alternative 46. Alternative C is expected to have greater direct adverse effects to individual double-crested cormorants and the double-crested cormorant colony on East Sand Island than Alternative B, but less than Alternative D. Under Alternative C, abundance of the western population of DCCOs is expected to be greater than ca. 1990 abundance. Since 1990, the growth of the western population of DCCOs has been primarily associated with the growth of the East Sand Island colony. Thus, it appears that the western population of DCCOs is sustainable at approximately ca. 1990 numbers. A sustainable population is defined for this analysis as a population that is able to maintain numbers above a level that would not result in a major decline or cause a species to be threatened or endangered.

The preferred management plan would have two phases. Phase I is expected to last approximately four years and is scheduled to begin March 2015, when the Corps proposes to begin culling DCCOs to a target size of 5,380–5,939 breeding pairs to reduce predation impacts on juvenile salmonids. A depredation permit application would be submitted to the USFWS and need to be approved prior to implementation. The Corps would request technical assistance from USDA-WS in directly implementing the plan. Phase II includes actions to ensure the number of DCCOs on East Sand Island does not exceed 5,380–5,939 breeding pairs. In Phase II no efforts would be made to maintain a minimum DCCO colony size on East Sand Island or to reduce the DCCO abundance below the target size. The majority of management activity would take place on the western portion of East Sand Island (Figure 5-1).

FIGURE 5-1. East Sand Island DCCO nesting and use area where the majority of management actions would take place.

Proposed Management Plan

Phase I

Mobilization and Field Preparation

Field crew personnel would arrive on East Sand Island each year (typically before nesting season) to transport supplies and equipment and make any necessary preparations for management that year. Temporary housing (i.e., tents or weatherports) would be constructed and maintained, as personnel would be present 24 hours a day during the period of active hazing. Individuals would follow designated travel routes to minimize potential impacts on other wildlife. Travel by all-terrain vehicles (ATVs) would occur along compacted sand along the shore, or on previously established ATV paths. Boat landing and loading points would be chosen to eliminate potential disturbance. Protective fences would be used to conceal hazing activities from designated nesting areas. Established best management practices for housekeeping would be used to minimize human impacts on vegetation.

Crews would repair or construct privacy fences, above ground tunnels, and other temporary habitat modification techniques (i.e., ropes, flags, and stakes) for field work. Personnel would observe DCCOs from blinds or similar structures, and the following observations or behaviors outside of the designated nesting area would trigger a hazing event: 1) DCCO breeding behavior (i.e., courtship, nest building, or copulation); 2) more than 50 DCCOs loafing in an area; and 3) DCCOs present at twilight (i.e., preparing to roost overnight). Hazing triggers would be adapted if they are ineffective at producing desired results. Other visual and noise deterrents could be used during hazing events as needed depending on effectiveness of human hazers and knowledge gained during implementation. Human hazers would begin to restrict DCCOs from nesting in areas outside designated colony area. Any temporary habitat modification techniques would be removed, when appropriate, to reduce potential impacts to non-target species and to ensure materials are not damaged or lost over winter.

Culling

Take of individuals would occur by use of firearms with non-toxic ammunition. Lethal take would occur in two generally defined areas in relation to East Sand Island: 1) off-island in the foraging area and 2) on-island. Boat-based hazing and hazing on East Sand Island would occur separate from or in conjunction with shooting. Noise associated from boat-based shooting would also be used to deter DCCO foraging. Noise deterrents would be used as appropriate in hazing efforts over water. The Corps would initially undertake a 4-year lethal strategy to achieve the target size, with the annual take levels proposed in Table 5-1. Based on first year's results and adaptive thresholds, the lethal strategy could be adjusted to a 3- or 2-year lethal strategy, with the annual take levels proposed in Table 5-1.

TABLE 5-1. Proposed Take Levels under the 4-year Lethal Strategy and the Adjusted 3- and 2-year Lethal Strategies.

	4-year strategy			Adjusted 3-year strategy			Adjusted 2-year strategy		
Year	# ind taken	% of colony	associated active nests lost[1]	# ind taken	% of colony	associated active nests lost[1]	# ind taken	% of colony	associated active nests lost[1]
1	5230	20.3%	5230	5230	20.3%	5230	5230	20.3%	5230
2	4270	20.3%	4270	6071	28.8%	6071	10156	48.0%	10156
3	3533	20.3%	3533	4489	28.8%	4489			
4	2923	20.3%	2923						
Total	15956		15956	15790		15790	15386		15386

[1]Lethal take of individuals is the proposed direct lethal action. Nest loss values represent the upper bound of potential egg loss that could occur indirectly from taking individuals. The time period of active nests is from egg laying to presence of fledglings. For associated active nests lost, actual numbers would be recorded and reported when determination in the field can be made. If determination cannot be made in the field, March 27 to July 25 would be date range used to report associated active nests lost.

* Take numbers and percentages are mid-points between the two carrying capacity scenarios modeled in Appendix E-2. The Corps would initially undertake the 4-year lethal strategy and use the associated take levels when applying for a depredation permit application. The adjusted 3-year or 2-year could be selected if the proposed take levels for the respective strategy are expected to be achieved by June 26 (pending implementation) and the frequency of culling to achieve the proposed take levels would not exceed the lower dispersal threshold (observed abundance 70 percent or less than the expected abundance one week after a culling session).

Culling would be attempted off-island from boats or at distance sufficient enough not to prevent DCCOs from nesting within the designated nesting area on East Sand Island. The lethal technique used for off-island culling would be shooting with shotguns and directly approaching DCCOs with boats and shooting once in effective range or situating boats and individuals in the flight path of DCCOs. Training would occur to minimize misidentification and take of non-target species during all culling efforts.

Culling on-island would initially be attempted as early in the year as possible and before active nests are present to determine the feasibility of lethally removing individuals without causing excessive DCCO dispersal. Excessive dispersal would be determined by a dispersal threshold, which is identified as an observed abundance that is 70 percent or less than the expected post-take abundance one week after the culling event. Multiple individuals would be shooting from observation points (ground or elevated) and existing structures on East Sand Island using small caliber rifles. Culling would occur periodically on-island, with the intention that a primary core nesting area would be left unaltered if take targets can be achieved. After a culling event, the island would be left undisturbed until another culling session occurs. Culling may occur during the day on-island, if privacy fencing is sufficient in precluding disturbance in other areas, and if proximal DCCOs are not disturbed when lethal take occurs. However, if day-time culling on-island results in high levels of dispersal or impacts to non-targets, culling on-island would occur primarily or only at night. If noise from firearms causes excessive dispersal or indirect impacts to non-targets, silencers and sub-sonic (i.e., slower than the speed of sound) shot would be used primarily or only.

Carcasses would be retrieved and removed immediately, or as soon as feasible, after the conclusion of lethal take. This would occur on-island after a culling session in a manner that minimizes disturbance to non-target nesting DCCOs and other non-target nesting species. If shooting occurs at night, retrieval could occur the following day. For culling off-island, where culled individuals would fall in open water, take activities would cease frequently enough in order to retrieve culled individuals while they are in the proximal area, or other boats and personnel would monitor or be positioned away from the site of culling to retrieve carcasses (i.e., downriver, along shorelines). DCCO carcasses would be examined for leg bands or other markers, and reported to the USGS Bird Banding Laboratory or other appropriate entity. When possible, lethally removed birds or eggs would be donated to a public educational, scientific institution, Non-Eagle Feather Repository, or other entities authorized to possess birds. Carcasses not donated for these purposes would be disposed of following standard conditions of 50 CFR 21.41, which include burial and incineration, and any special conditions specified in a depredation permit.

Monitoring and Adaptive Management

The Corps would initially undertake the 4-year lethal strategy, which includes annual take of 20.3 percent of the breeding individuals per year, or approximately 5,230, 4,270, 3,533, and 2,923 DCCOs in years 1 to 4, respectively. The 4-year lethal strategy could be adjusted to a 3- or 2-year strategy by increasing take levels after the first year of lethal management. The benefits of a shorter lethal take strategy would be less overall adverse effects from management activities to the DCCO colony and other species on East Sand Island and reduced implementation costs. Take percentage in year 2 and 3 could be increased to 28.8 percent for the adjusted 3-year strategy (6,071 and 4,489 DCCOs taken in year 2 and 3) or 48.0 percent for the adjusted 2-year strategy (10,156 DCCOs taken in year 2; Table 5-1). The Corps would submit an annual depredation permit application to the USFWS for the proposed individual take levels and associated nest loss from take of those individuals.

The thresholds for adjusting year strategies would be based upon the first year's culling efficiency (i.e., the number of DCCOs lethally taken per day of culling and the total number of days from the first to last culling session) and the frequency that culling took place does not exceed the lower dispersal threshold (i.e., observed abundance is 70 percent or less than the expected abundance one week after a culling event; Table 5-2). The adjusted 3-year or 2-year lethal strategy could be selected if the proposed take levels for the respective strategy are expected to be achieved by June 26 (i.e., approximate mid-point of when active nests are typically present on East Sand Island [March 27–July 25]) and the frequency of culling to achieve the proposed take levels would not exceed the lower dispersal threshold. If this could occur, the Corps, in consultation with the Adaptive Management Team, would then consider adjusting year strategies. Selecting this date (June 26) as a measure for adjusting future years' proposed take levels would be contingent upon implementation occurring as planned.

The proposed take levels in Table 5-1 would be followed by the Corps for requesting take levels in an annual depredation permit application. Lethal take within a given year would cease once annual take levels, authorized in an annual depredation permit, are achieved, or the target colony size, based on peak annual abundance, is achieved. The proposed take levels could be adjusted if the peak observed annual colony size during late incubation deviates from predicted annual colony size (see Appendix E-2) greater than what is expected due to natural annual variation in colony size. Annual variation in colony size is expected. During 2004 to 2013, the average percentage change in colony size between consecutive years was 11 percent; the greatest percent change was 21 percent between 2012 and 2013 (see Figure 1-2). The take levels proposed under all year strategies could decrease if peak observed annual colony size during late incubation, accounting for expected annual variation, becomes lower than model predicted colony size. If peak observed colony size becomes greater than model predicted colony size, additional NEPA review and supporting analyses would be required for increased take levels greater than those proposed and analyzed in the EIS. Any adjustment to year strategies or proposed take levels would occur in coordination with the Adaptive Management Team.

On- and off-colony take efforts (i.e., type, frequency, and duration) and other non-lethal methods would be adjusted depending on effectiveness of technique and resulting dispersal levels in comparison to the identified dispersal threshold (Table 5-2). Management actions would be adjusted to avoid a large proportion of DCCOs dispersing to upriver locations. A large disparity between the reduction in colony abundance and the known number of individuals taken accompanied with increased DCCO abundance in the Columbia River Estuary upstream of the typical known foraging range of DCCOs from East Sand Island (i.e., 25 km; Anderson et al. 2004a) would be suggestive of increased DCCO dispersal from East Sand Island. Lethal take would resume when DCCO abundance on East Sand Island returns to greater than 90 percent of the expected colony size and hazing efforts in the estuary are sufficient to adequately deter the number of DCCOs present from foraging in upriver locations (Table 5-2).

TABLE 5-2. Culling and Adaptive Responses in Phase I.

Action	When Used	Monitoring Effort	Adaptive Response
Culling Off-Island	DCCO foraging in the estuary (over water) within 25 km of East Sand Island	Boat-based surveys, field crew observations	If DCCO become wary to shooting off-island from associated disturbance and noise, culling off-island could change locations within the foraging area (25km) to increase effectiveness. Take would occur primarily on-island if off-island culling is ineffective.
Culling On-Island	DCCO present on island (prior to and during nesting season)	Field crew observations, aerial surveys	If the observed abundance is 70 percent or less than the expected abundance one week after a culling event, management actions could be changed or scaled back until abundance returns to at least 90 percent of the expected abundance. Initially, culling would be attempted as early in the year as possible, but, if the lower dispersal threshold (70 percent or

Action	When Used	Monitoring Effort	Adaptive Response
			less than expected abundance one week after a culling event) is exceeded, culling would not occur until DCCO are observed building and attending active nests (late April). Changes in management actions to reduce dispersal so as not to exceed the lower dispersal threshold (70 percent or less than expected abundance one week after a culling event) include: Conduct culling primarily or only at night Use of silencers and sub-sonic shot primarily or only Increase amount of privacy fence Decrease frequency and intensity of culling The Corps would initially undertake the 4-year lethal strategy. The adjusted 3-year or 2-year lethal strategy could be selected if the proposed take levels for the respective strategy are expected to be achieved by June 26 (pending implementation) and the frequency of culling to achieve the proposed take levels would not exceed the lower dispersal threshold (70 percent or less than expected abundance one week after a culling event). Take percentage in year 2 and 3 could be increased to 28.8 percent for the adjusted 3-year strategy (6,071 and 4,489 DCCOs taken and associated active nests lost in year 2 and 3) or 48.0 percent for the adjusted 2-year strategy (10,156 DCCOs taken and associate active nests lost in year 2). Proposed individual take levels would include and account for the associated amount of indirect nest loss that could occur from taking the proposed number of individuals. The take levels proposed under all year strategies could decrease if peak observed annual colony size during late incubation, accounting for expected annual variation, becomes lower than model predicted colony size. If peak observed colony size becomes greater than model predicted colony size, additional NEPA review and supporting analyses would be required for increased take levels greater than those proposed and analyzed in the EIS. Any adjustment to year strategies or proposed take levels would occur in coordination with the Adaptive Management Team. Other lethal techniques identified and described in Chapter 2, section 1.2 (i.e., egg addling/destruction/oiling, traps/nets or capture techniques, and euthanasia) could be used depending on knowledge gained during implementation, and review through the Adaptive Management Team. Use of these techniques could require additional NEPA review.

Impact Avoidance and Minimization Measures

To minimize impacts to non-target species during hazing, preference would be given to visual deterrents first and noise deterrents second as a means to minimize impacts to non-target species. Monitoring to determine when hazing events are needed would be done via field crew observations from ground positions. DCCOs and other birds would be monitored from concealed areas or distances sufficient not to induce flushing. If monitoring within the colony is necessary, it would be kept to as short a time duration as possible and would not occur in severe weather conditions or when higher than normal levels of predation might be expected.

To minimize take of non-target species during culling on- and off-island, a shooting protocol would be developed prior to implementation. Shooters would receive species identification training and trained individual or biologist(s) in species identification would be present when lethal take occurs to minimize take due to misidentification (i.e., Brandt's and pelagic cormorants). Areas or lethal take opportunities that have a high concentration of non-target species present would be avoided. Species would be identified prior to night shooting, and, if there is a high concentration of non-target species in the area that could be misidentified, these areas would be denoted and avoided.

Techniques and methods would also be modified to minimize take of non-target species if it should occur. These actions include increasing the amount of training for personnel, increasing the number of individuals in the field adequately trained in species identification, removing personnel unable to adequately perform duties, ceasing that particular lethal technique, or avoiding mixed species areas. All individuals taken and associated active nests lost for all species would be recorded, and information would be provided to meet reporting requirements. Informal reporting of field conditions and events could occur more frequently. When determination of active nest loss can be made in the field, the actual number of active nests lost would be recorded and reported. When determination of DCCO active nest loss cannot be made in the field or the date that active nests are first present on East Sand Island during a given year is unknown, the date range of March 27 to July 25 would be used to report associated nest loss.

To assure culling would not result in risk to human safety, personnel would adhere to all safety standards of firearm operation and training as described in the USDA-WS Policy Manual, Directive 2.615 (Firearm Use and Safety), and Firearms Safety Training Manual. The use of firearms would be conducted in accordance with all local, state, and Federal regulations. Personnel would implement precautionary measures to reduce risk to public safety, such as positively identifying target animals before shooting, ensuring a backstop should the bullet miss, using rifles that fire single projectiles per shot, and using only specially trained personnel.

To the extent possible, areas and times of public usage would be avoided when implementing management actions on- and off-island. Monitoring would occur before shooting to ensure people are not present within the targeted area or shooting direction. East Sand Island would be closed to the public during implementation, and any violations of the closure or interference to management activities would be enforced as specified in 18 U.S.C. 111.

Hazing DCCOs in the Columbia River Estuary

Boat and land-based hazing would be conducted on the primary monitoring locations identified in Table 5-3, as well as other areas in the Columbia River Estuary that meet the hazing triggers. Boat-based hazing would be used to deter DCCO foraging, particularly at up-river locations where predation impacts are known to be greater (Collis et al. 2002). If necessary, noise deterrents (i.e., pyrotechnics, cracker shells, etc.) would be used to aid hazing efforts over open water. It may not be possible to entirely limit DCCO expansion into new areas in the estuary, given the geographic scope, difficulty in accessing some sites due to logistics or landowner permission, and potential overlap with ESA-listed species (i.e., streaked horned lark) or other species of conservation concern. Potential DCCO dispersal locations within Columbia River Estuary may be in areas that the Corps does not own or have the right to access. Any potential actions in these areas would need to be coordinated with the appropriate landowner(s) or interested parties, prior to implementation.

TABLE 5-3. Monitoring and Potential Hazing Locations in Columbia River Estuary.

Key Estuary Monitoring/Hazing Locations*	Hazing Triggers
Astoria-Megler Bridge	1) Breeding behavior is observed 2) >50 DCCOs loafing or roosting 3) DCCOs present at twilight
Rice Island	
Miller Sands Spit	
Pillar Rock Island	
Lewis and Clark Bridge	
Troutdale Transmission Tower	
Willamette Falls/Oregon City	
Bonneville Dam	
Tongue Point Piers	

*Additional locations for hazing would be determined from the results of surveys and monitoring.

Efforts to haze on lower estuary islands would be integrated with on-going avian predation management of dredge materials sites under the Corps' Channel and Harbors program, which monitors dredged material placement sites for DCCO and Caspian terns and implements hazing as needed to prevent these species from nesting in upland disposal sites (see Chapter 4, section 4.5). On dredged disposal islands, land-based hazing and habitat modification could occur early in the nesting season and at a distant sufficient to prevent impacts to non-target species, especially streaked horned larks. Due to the potential for adverse effects to streaked horned larks, an adaptive monitoring and hazing plan would be coordinated with the USFWS Endangered Species programs. The Corps would submit a depredation permit application for take of up to 250 DCCO eggs on the Corps' dredged material sites so that placement of temporary habitat modification (flags, ropes, and stakes) and hazing can continue after the beginning of the breeding season and the alternative is feasible and effective to implement. Egg take on Corps' dredged disposal islands would be minimized to the extent possible by: 1) implementing actions frequently enough so that nest destruction and hazing occur before egg laying; 2) ceasing hazing and habitat modification techniques within a sufficient distance of an active nest (i.e., once an egg is laid); 3) removing nesting materials or destroying nests only if the nest does not have egg(s) in it; and 4) reducing or ceasing hazing if higher than normal levels of subsequent predation might be expected.

Monitoring and Adaptive Management

Monthly aerial surveys and high resolution aerial photographs would be taken over East Sand Island during the breeding season to estimate peak colony size (see Table 5-4 for proposed monitoring). Target size achievement would be based upon the peak breeding season colony size (i.e., typically late incubation). Individual take and associated nest loss and any other reporting specifications of a depredation permit would be monitored and reported. PIT tag recoveries on East Sand Island would occur after the breeding season. The average annual percentage of available PIT tags that are recovered in the DCCO nesting area would be evaluated in context of relevant factors to assess DCCO predation rates of juvenile salmonids.

Concurrent with East Sand Island actions, aerial, boat, and land-based surveys would be conducted to determine if DCCOs dispersed from East Sand Island are relocating within the estuary. Short-term and short-distance dispersal from management activities (Roby et al. 2012, 2013, 2014) and daily movements for foraging (foraging range typically < 25 km; Anderson et al. 2004a) are expected. During the primary lethal take period on East Sand Island, surveys would be conducted 2-3 days after the culling session to assess dispersal levels and could continue until July 31 each year. Surveys would decrease in frequency after take ceases and would supplement monthly aerial surveys, as necessary. Less than five crews would likely be needed.

Up to five monitoring crews would be deployed throughout the Columbia River Estuary. Each crew would be responsible for monitoring approximately 30–40 RM of the Columbia River Estuary. The number of DCCOs roosting, resting, or attempting to nest at specific locations would be counted and recorded. Additionally, monitoring crews would conduct short-interval point counts (i.e., 15 minute) from set, stationary positions within their monitoring areas multiple times per day (i.e., morning, mid-day, and evening) to monitor abundance of foraging and flying DCCOs.

Priority areas in coastal Washington and Oregon where there are fish predation concerns and the potential for DCCO increases were identified through input from cooperating agencies and the utilization of past results from dissuasion experiments. In Oregon, these areas are the coastal estuaries and lakes. In Washington, these areas are Willapa Bay National Wildlife Refuge, Gray's Harbor, Puget Sound, and San Juan Islands. The Columbia River Basin above the Bonneville Dam was also identified as a priority area. Annual aerial surveys of these areas would occur at least once during the peak breeding season from April 1–July 31 to monitor abundance. Surveys in the Columbia River Basin above Bonneville Dam would occur in coordination with the Corps' Walla Walla District's Inland Avian Predation Program. Monitoring frequency could change, depending upon DCCO response and information needs.

Data collected from these monitoring efforts would augment the USFWS and Pacific Flyway Council regional monitoring strategy for the western population of DCCOs (Pacific Flyway Council 2013). This monitoring strategy was developed through the Pacific Flyway Council as a joint effort between federal and Pacific Flyway state agencies to assess DCCO population status, distribution, and trends (Pacific Flyway Council 2013). The Corps would follow the prescribed monitoring protocols, coordinate efforts, and share monitoring data to the greatest extent possible with these monitoring efforts.

If monitoring efforts show DCCO increases in areas, the Corps would notify and coordinate with ODFW, WDFW, or other appropriate land managers. The agency or entity that would lead any potential management actions and the extent of management techniques could vary, depending upon the location and DCCO impacts. Mere presence of DCCOs may not indicate a problem that needs to be addressed. If conflicts result, the best management strategy for addressing any potential DCCO conflicts at these locations would be determined in the future and should follow existing and appropriate processes for resolving DCCO conflicts within the Pacific Flyway (Pacific Flyway Council 2012).

Adaptive management thresholds would be used to adjust techniques and monitoring (see Table 5-4). In-season and prior year observation of DCCO nesting locations and density would be used to determine the location and amount of available nesting habitat. Dispersal levels would be estimated from colony counts on East Sand Island and abundance surveys in the Columbia River Estuary, above Bonneville Dam, and in priority coastal areas in Washington and Oregon. Survey frequency and areas within the Columbia River Estuary, above Bonneville Dam, and coastal Washington and Oregon could be adjusted based upon DCCO response and knowledge gained during implementation. Management would be considered successful once the DCCO target colony size is achieved and maintained, and the Corps would continue to implement non-lethal methods, as necessary, to maintain the target size.

The amount of nesting habitat reduction on East Sand Island and frequency and duration of hazing on East Sand Island and in the Columbia River Estuary would be adjusted so that incremental dispersal of DCCOs from the Columbia River Estuary would occur each year until the target size is achieved. Non-lethal techniques supported with limited egg take could be changed or adjusted, based on knowledge gained during implementation. Adjustments in techniques would be coordinated through the Adaptive Management Team and specified in depredation permit applications, as necessary. Hazing triggers on East Sand Island and in the Columbia River Estuary would be adjusted if they are inadequate in achieving desired response. Hazing efforts in the Columbia River Estuary would be adjusted to minimize impacts to or take of other species, particularly streaked horned larks. The amount of egg take requested in an annual depredation application would be adjusted based on the prior year's results.

TABLE 5-4. Monitoring and Adaptive Responses in Phase I.

Management Need	Proposed Monitoring and Frequency	Adaptive Response
Detect Reduction of Colony Size on East Sand Island	Monthly aerial surveys and high resolution photographs, visual observations of field crews, monitor for dispersal.	Increase frequency of aerial surveys to weekly if observed abundance is 70 percent or less than the expected abundance one week after a culling session. Management actions could be changed or scaled back until abundance returns to at least 90 percent of the expected abundance.
Monitor and Hazing of DCCOs in Columbia River Estuary at Priority Areas	Boat- and land-based surveys and hazing every other day per week during peak nesting, surveys every three days outside of peak nesting in foraging area of East Sand Island. Bi-weekly surveys in upriver locations. Monthly aerial surveys.	Increase frequency of boat- and land-based surveys and hazing to daily if surveys in the estuary detect >4,000 DCCOs demonstrating breeding behavior at locations other than East Sand Island. Decrease frequency of surveys and hazing to weekly or daily if no DCCOs present at location in three consecutive surveys. Aerial surveys same threshold as East Sand Island.
Detect DCCOs outside of Columbia River Estuary - (Columbia River Basin, Coastal OR and WA) - Monitor Western Population of DCCO	Aerial surveys Level 1 - Annual Level II - Bi-annual Level III - Tri-Annual	Increase frequency of aerial surveys to weekly if observed abundance is 70 percent or less than the expected abundance one week after a culling session and this number of DCCOs is not detected in the Columbia River Estuary. Surveys coordinated with USFWS seabird surveys and Pacific Flyway Council monitoring strategy.

Management Need	Proposed Monitoring and Frequency	Adaptive Response
Minimize Impacts to Non-target Species	Daily observations of field crews, DCCO daily responses, nesting attempts and productivity, presence of bald eagles, and response of non-targets.	If monitoring indicates effects to non-target species greater than anticipated and evaluated in the EIS, management actions would be scaled back or techniques changed to more passive measures in-season and in future years. Management strategies would change to more habitat modification prior to nesting season (April-May) in the following year. Boat-based or aerial monitoring would occur at a distance that does not induce flushing.
Minimize Impacts to Streaked-Horned Larks in Columbia River Estuary	Boat- and land-based surveys (some surveys are ongoing per Corps' Channels & Harbors Program) weekly to daily, observations by field crews monitoring for DCCOs.	Coordinate surveys with Corps' Channels & Harbors Program and develop hazing effort consistent with ESA requirements; annual meetings with USFWS to determine future monitoring and management actions.
Assess Predation Rates	PIT tag recoveries post-breeding season.	No adaptive response in Phase I because the time period is too short to determine trends. Use is for evaluation of overall multi-year effectiveness of management.

Phase II

Management Actions to Reduce Colony Size on East Sand Island and Deter Nesting and Foraging in Columbia River Estuary

Continued non-lethal management on East Sand Island is expected to be necessary to slow or stop abundance increase of the colony. The goal of Phase II is to transition to lower maintenance non-lethal techniques and reduce the amount of human presence needed on the island while still ensuring the target colony size is not exceeded. This would be accomplished through terrain modification and supplemented with temporary habitat modification and hazing, as necessary (see Table 5-5). Hazing techniques would be the same as described in Phase I, and the extent of hazing would depend upon DCCO response to management and the capacity of the colony to increase in size after Phase I targets are reached. Based on knowledge gained during Phase I, a minimal amount of egg take on East Sand Island would most likely be requested in a depredation permit application to ensure that the alternative can be implemented effectively (see Table 5-5). Terrain modification would occur through the excavation of sand, in order to inundate the DCCO nesting area (Figure 5-2). Sand would be excavated to an elevation that would be inundated at least once per week during April 1-July 15, and to a water depth of 6 inches to 1 foot to preclude nesting attempts or success. Two "lagoon" type areas open to tidal fluctuations via five channels on the north side of the island would be created on the western portion of the island. The shoreline would be armored with added rock (riprap) on the north side to reinforce the island and maintain stability of the federal navigation channel. Disposal of excavated sand could be used as beach nourishment placed between the pile dikes on the southern shoreline, on the eastern portion of the island in order to supplement the soils on the designated Caspian tern colony, or to help stabilize the island from further erosion on the southeastern shore. Construction activities would take place within the in-water work window (November 15-February 15).

FIGURE 5-2. Proposed terrain modification, creating "lagoon" type areas in the DCCO nesting area on the western portion of East Sand Island.

Similar to dissuasion research methods, habitat modification combined with human hazing would be used to restrict DCCO nesting area. Privacy fences would be constructed to designate this area prior to birds arriving on the island (Feb-Mar). Based on prior estimated maximum DCCO nesting density on East Sand Island (1.28 nests per square meter; BRNW unpublished data), the amount of available nesting habitat may ultimately need to be reduced to 1.04–1.15 acres or less in order to achieve the target colony size. Hazing techniques would be the same described in Phase I. Lethal methods would not be used in Phase II to constrain the colony, but the Corps would apply for an annual depredation permit for up to 500 DCCO eggs to successfully implement hazing after the beginning of the breeding season to effectively implement the alternative.

TABLE 5-5. Proposed Active Methods for Phase II and Long-term Management of the DCCO colony.

Action	When Used	Adaptive Response
Designate Nesting Area	Prior to nesting season (Feb-Mar). Habitat reduction is based on known nesting densities of 1.28 nests per square meter.	Decrease available nesting area as needed and as densities increase greater than 1.28 nests per square meter based on peak colony size and density.
Human Hazing	Outside designated nesting area if breeding behavior observed, >50 DCCO observed loafing, or DCCOs observed at twilight about to roost.	Reduce threshold to 25 (or fewer) DCCOs loafing if greater hazing intensity needed. If DCCO habituate to human hazing, apply visual deterrents to increase effectiveness in hazing. Dogs could be used selectively if human hazing is not effective.
Visual Deterrent	If DCCO habituate to human hazing.	If DCCO habituate to visual deterrents, apply noise deterrents.
Noise Deterrent	During boat-based hazing in foraging area and if DCCO habituate to human hazing and visual deterrents.	If DCCO habituate to noise deterrents, combine additional methods.
Temporary Habitat Modification (stakes, ropes, and flagging)	Concurrent with hazing. Apply temporary habitat modification prior to or during nesting season.	Increase amount and area.
Egg Collection	Concurrent with hazing. The Corps would submit a depredation permit application for take of up to 500 DCCO eggs.	Take numbers adjusted in subsequent years based on take during the prior year.

Monitoring and Adaptive Management

Annual monitoring to estimate DCCO abundance, nesting density, and PIT tag recoveries on East Sand Island would continue as necessary (Table 5-6). Peak breeding season colony size would be determined from counts during late incubation. An average 3-year peak breeding season colony size estimate would be used for evaluating actual colony size to target size. If personnel are on the island conducting hazing activities, DCCO counts and behavior and response of non-target species would be monitored and reported. PIT tag recoveries would be used to evaluate effectiveness of management actions in reducing predation of juvenile salmonids. Due to annual variability in predation impacts, monitoring would likely need to occur over a longer period of time (5-10 years) to assess overall trends and effects, accounting for yearly fluctuations.

Abundance surveys would continue, as needed, to determine DCCO abundance at other locations within the Columbia River Estuary. The same strategy as Phase I would be used to deter DCCO nesting and foraging in the Columbia River Estuary. Efforts would likely be less in

Phase II if hazing efforts in Phase I are successful in redistributing DCCOs outside of the Columbia River Estuary. Monitoring would likely be less than during Phase I and would concentrate on known areas of concern or interest. Annual monitoring efforts in coastal areas of Washington and Oregon and above Bonneville Dam would cease in Phase II. Monitoring efforts would match or supplement those of the Pacific Flyway Council monitoring strategy (Pacific Flyway Council 2013).

Based on Phase I and II implementation and response of DCCOs, management actions would be adjusted accordingly to ensure the target colony size and associated base period DCCO predation conditions are not exceeded. These actions would be conducted as necessary and would continually transition to methods that are most effective, least impactful to non-target species, and require least management effort and cost. Actions would be considered successful when the average 3-year peak colony size estimate does not exceed the target colony size while no management actions are conducted. The Adaptive Management Team would develop a more detailed strategy outlining actions and appropriate monitoring based on Phase I and II results for long-term DCCO management in the Columbia River Estuary. Continuance of long-term monitoring and management would depend upon available appropriations and future management needs. Additional environmental review may be needed at that time.

TABLE 5-6. Monitoring and Adaptive Responses in Phase II.

Management Need	**Proposed Monitoring and Frequency**	**Adaptive Response**
Detect Peak Colony Size on East Sand Island	Aerial surveys (3-year average)	If DCCO colony size is greater than 5,600 pairs after 3 year average, management actions could be implemented to haze or place temporary habitat modification materials (ropes, flags, stakes) supported with limited egg take to reduce nesting. Management actions would be scaled back or techniques changed to more passive measures in-season and in future years to avoid impacts to non-targets.
Monitor DCCOs in Columbia River Estuary at priority areas	Annual aerial surveys	Coordinate with Corps' Channels and Harbors Program to document potential increases in DCCO on dredged material islands. Increase frequency of surveys if needed.
Monitor Western Population of DCCO	Aerial surveys every three years at selected colonies per Pacific Flyway Council monitoring strategy	Coordinate with USFWS and Pacific Flyway Council to determine effectiveness of survey methodologies. Increase frequency of surveys or locations based on information needs.
Assess Predation Rates	PIT tag recoveries - post-breeding season	No adaptive response in Phase II until data has been collected for sufficient period of time (5-10 years) due to seasonal and annual variability in predation rates.

Chapter 6 Consultation and Coordination

In addition to the cooperating agencies, the Corps coordinated with the following agencies and groups during the development of this document: NOAA Fisheries and the US Geological Survey's Oregon Cooperative Fish and Wildlife Research Unit Department of Fisheries and Wildlife.

6.1 List of Primary Preparers

Name and Affiliation	Position and Contribution to EIS	Education	Years of Experience
U.S. Army Corps of Engineers Elisa Carlsen	Social Scientist Technical writer/editor - all sections, affected environment - public resources	B.A. Cultural Anthropology	11
U.S. Fish and Wildlife Service Michelle McDowell	Wildlife Biologist Population Modeling, QA/QC Review Technical assistance to minimize impacts to DCCO and other migratory birds	B.A., Biology M.S., Wildlife Science	19
U.S. Department of Agriculture- Wildlife Services Kevin Christensen	Wildlife Biologist, Assistant State Director Chapter 2 – Alternatives Chapter 4 – Effects	B.S. Fisheries and Wildlife Management	17
U.S. Department of Agriculture- Wildlife Services Matt Alex	Wildlife Specialist Chapter 2 – Alternatives Chapter 4 – Effects	B.S. Fisheries and Wildlife Science	8
Harris Environmental Josh Dooley	Environmental Planner Technical writer/editor - all sections - Affected Environment - Environmental Consequences DCCO, other Birds, Population Modeling	B.S. Env. Biology M.S. Wildlife Management	10
Harris Environmental Lirain Urreiztieta	Graphic / GIS	M.S. GIS	13
Harris Environmental Dietrich Walker	Technical editor – all sections	B.S. Geography M.S. GIS	6
Lower Columbia Research & Archaeology LLC Melissa Darby	Senior Archaeologist/Historian Affected Environment Historic Properties	M.A. Anthropology	20
Green Banks LLC C. Jonas Moiel	Senior Ecologist Affected Environment - Wetlands	B.S. Env. Science, M.E.M. (Master of Environmental Management) Ecology	13

USFS Restoration Services Lynda Moore	Restoration Botanist Affected Environment, Environmental Consequences Vegetation Communities East Sand Island	B.S. Botany M.S. Environmental Sciences and Management	10
Real Time Research Allen Evans	Fisheries Scientist Affected Environment Fish (chapters 3.2.5 -3.2.7) Environmental Consequences Fish (Tables 12-13) PIT tag summaries (Appendix C) ESA Fish Lists (Appendix H)	B.A. Biology M.S. Fisheries and Wildlife	20
Pacific Northwest National Laboratory Heida Diefenderfer	Restoration Ecologist Climate Change Effects Review / Analysis, Phase II – Terrain Modification	B.A. Biology B.A. Cultural Studies M.A. English-Cultural Studies Ph.D. Forest Resources	20
Pacific Northwest National Laboratory Andre Coleman	Geospatial Engineer Climate Change Effects Review/Analysis, ATIIM Modeling, Affected Environment - Inundation, Environmental Consequences - Inundation, Phase II - Terrain Modification	B.S. Geography & Earth Resources M.S. Geoinformatics	20
Pacific Northwest National Laboratory Nichole Sather	Fisheries Scientist Climate Change Effects Review/Analysis	A.A. General Studies B.S. Environmental Science M.S. Fisheries Science	13
Pacific Northwest National Laboratory Amy Borde	Wetlands Ecologist Climate Change Effects Review/Analysis, Phase II - Terrain Modification	B.S. Biology B.S. Env. Pol. & Management	20
The Research Group Shannon Davis	Econometrician Chapter 3 and 4 - Appendix I salmonid adult return and fisheries economic contribution simulation modeling	M.S. Quantitative Studies	30
The Research Group Hans Radtke	Natural Resource Economist Chapter 3 and 4 - Appendix I economic effects write-up	Ph.D. Economics	40
The Research Group Christopher Carter	Natural Resource Economist Chapter 3 and 4 - Appendix I economic effects write-up	Ph.D. Economics	35

6.2 List of Agencies, Organizations, and Persons to Whom Copies of the Environmental Impact Statement Were Sent

An email distribution list was created with over 150 interested parties, non-governmental organizations, federal, state and local agencies, and other private individuals. The draft EIS and link to the Federal Register notice was sent electronically to this email list. Notice of the public meetings to be held in Astoria, Oregon and Portland, Oregon was also sent to this email distribution list and a press release was issued to media groups in the region.

NON-GOVERNMENTAL ORGANIZATIONS (NGOs) - Portland Audubon Society, Seattle Audubon Society, Audubon Society of Lower Columbia Basin, Audubon Society of Willapa Hills, National Audubon Society, American Bird Conservancy, American Welfare Institute, American Society for the Prevention of Cruelty to Animals, Cascadia Wildlands, Center for Biological Diversity, Coastal Conservation Association, Columbia Basin Fish and Wildlife Authority, Columbia River Estuary Study Taskforce, Cormorant Defenders International, Defenders of Wildlife, Endangered Species Coalition, Federation of Fly Fishers, The Freshwater Fund, Friends of Animals, Humane Society of the U.S., Lower Columbia River Fish Enhancement Group, National Pest Management Association, National Wildlife Control Operators Association, National Wildlife Federation, Native Fish Society, Nature Conservancy, Northwest Environmental Advocates, Ocean Conservancy, Oregon Wild, Ornithological Societies of North America, Pacific Coast Federation of Fisherman's Association, Pacific Seabird Group, People for the Ethical Treatment of Animals, Salmon for All, Seabird Restoration Program, Sierra Club, Washington Ornithological Society, Western Environmental Law Center, Wild Fish Conservancy, Wild Salmon Center, Wild Fish Conservancy, Wild Earth Guardians, Wildlife Center of the North Coast, Wildlife Watch

ACADEMIC INSTITUTIONS - Oregon State University, Slater Museum of Natural History-University of Puget Sound

BUSINESSES - Alseas Sportsmans Association, National Aquaculture Association, Northwest Guides and Anglers Association, Northwest Sportfishing Industry and Association, Real Time Research, Washington State Coastal Trollers Association

CITY AGENCIES & GROUPS - The Cities and Ports of Astoria, Portland, Illwaco, Long Beach, Warrenton

COUNTY AGENCIES & GROUPS - Clatsop County, Clatsop County Fisheries Project, Hood River County, Pacific County, Wahkiukum

STATE AGENCIES & GROUPS - Oregon Department of Fish and Wildlife, Oregon Department of Environmental Quality, Oregon Department of State Lands, Oregon Department of Transportation, Oregon Fish and Wildlife Commission, Idaho Fish and Game, Washington Department of Fish and Wildlife, Washington Department of Transportation

FEDERAL AGENCIES - Bonneville Power Administration, Bureau of Reclamation, NOAA Fisheries, USFWS, USDA-WS, Environmental Protection Agency

COUNCILS & COMMISSIONS - Columbia River Inter-Tribal Fish Commission, Northwest Power and Planning Council, Pacific Fishery Management Council, Pacific Flyway Council, Pacific States Marine Fish Commission, Northwest Indian Fisheries Commission, Natural Resources Defense Council

TRIBAL GOVERNMENTS & STAFFS - The Tribal Leadership and/or Natural Resource Management Programs of: Burns Paiute Tribe, Chinook Indian Nation, Confederated Tribes of Coos, Lower Umpqua and Suislaw Indians, Confederated Tribes of the Colville Reservation, Confederated Tribes of the Grand Ronde, Confederated Tribes of the Stiletz, Confederated Tribes of the Umatilla Indian Reservation, Confederated Tribes of the Warm Springs Reservation, Coquille Indian Tribe, Cow Creek Band of Umpqua Indians, Cowlitz Indian Tribe, Jamestown S'Klallam Tribe, Klamath Tribes, Nez Perce, Port Gamble S'Klallam Tribe, Skokomish Nation, Spokane Tribe of Indians, Yakama Nation

Appendix A: References

Literature Citations

Adamus, Paul, Ph.D., Adamus Resource Assessment, Inc. 2006. Hydrogeomorphic (HGM) Assessment Guidebook for Tidal Wetlands of the Oregon Coast Part 1: Rapid Assessment Method. Produced by Coos Watershed Association.

Adamus, P. R. and D. Field. 2001. Guidebook for Hydrogeomorphic (HGM)–based Assessment of Oregon Wetland and Riparian Sites. I. Willamette Valley Ecoregion, Riverine Impounding and Slope/Flats Subclasses. Volume IA: Assessment Methods. Oregon Division of State Lands, Salem, OR.

Adkins, J. Y. and D. D. Roby. 2010. A status assessment of the double-crested cormorants (*Phalacrocorax auritus*) in western North America: 1998-2009. Final Report to the U.S. Army Corps of Engineers. Available on-line at www.birdresearchnw.org.

Adkins, J. Y., D. D. Roby, D. E. Lyons, K. N. Courtot, K. Collis, H. R. Carter, W. D Shuford, and P. J. Capitolo. *In press.* Estimated population size, trends, and limiting factors for the Double-crested Cormorant in western North America. Journal of Wildlife Management (accepted 2014).

Adrean, L. 2013. Avian Predation Program: 2012 Final Report. Oregon Department of Fish and Wildlife. Tillamook, Oregon.

Ainley, D. and D.W. Anderson. 1981. Feeding ecology of marine cormorants in southwestern North American. Condor 83:120-131.

Anderson, C. D., D. D. Roby, and K. Collis. 2004a. Foraging patterns of male and female double-crested cormorants nesting in the Columbia River Estuary. Canadian Journal of Zoology-Revue Canadienne De Zoologie 82:541-554.

Anderson, C. D., D. D. Roby, K. Collis. 2004b. Conservation implications of the large colony of double-crested cormorants on East Sand Island, Columbia River Estuary, Oregon, U.S.A. Waterbirds 27(2):155-164.

Anthony, R. G, R. W. Frenzel, F. B. Isaacs, and M. G. Garrett. 1994. Probable causes of nesting failures in Oregon's bald eagle population. Wildlife Society Bulletin 22:576-582.

Bedard, J., A. Nadeau, and M. Lepage. 1997. "Double-Crested Cormorant Culling in the St. Lawrence River Estuary: Results of a 5-Year Program." *Symposium on Double-Crested Cormorants: Population Status and Management Issues in the Midwest.* Paper 15. http://digitalcommons.unl.edu/nwrccormorants/15.

Beechie, T., H. Imaki, J. Greene, A. Wade, H. Wu, G. Press, P. Roni, J. Kimball, J. Stanford, P. Kiffney, and N. Mantua. 2012. Restoring salmon habitat for a changing climate. River Res. Applic.

Blackwell, B. F., M. A. Stapanian, and D. C. Weseloh. 2002. Dynamics of the double-crested cormorant population on Lake Ontario. Wildl. Soc. Bull. 30:345–353.

Borde, A. B., S. A. Zimmerman, R. M. Kaufmann, H. L. Diefenderfer, N. K. Sather, and R. M. Thom. 2011. Lower Columbia River and Estuary Restoration Reference Site Study: 2010 Final Report and Site Summaries. PNWD-4262, prepared for the Lower Columbia River Estuary Partnership and the Bonneville Power Administration by Pacific Northwest National Laboratory, Marine Sciences Laboratory, Sequim, WA.

Borde, A. B., V. I. Cullinan, H. L. Diefenderfer, R. M. Thom, R. M. Kaufmann, J. Sagar, and C. Corbett. 2012a. Lower Columbia River and Estuary Ecosystem Restoration Program Reference Site Study: 2011 Restoration Analysis. PNNL-21433, prepared for the Lower Columbia River Estuary Partnership by Pacific Northwest National Laboratory, Richland, Washington.

Borde, A. B., R. M. Kaufmann, V. I. Cullinan, S. A. Zimmerman, and C. L. Wright. 2012b. Lower Columbia River and Estuary Habitat Monitoring 2011 Annual Report. PNNL-21128, prepared for the Lower Columbia River Estuary Partnership by Pacific Northwest National Laboratory, Richland, Washington.

Borde, A. B., S. A. Zimmerman, R. M. Kaufmann, R. M. Thom, and C. L. Wright. 2013. Lower Columbia River and Estuary Habitat Monitoring Study, 2012 Annual Report. PNNL-22410, prepared for the Lower Columbia River Estuary Partnership by Pacific Northwest National Laboratory, Richland, Washington.

Bottom, D. and K. Jones. 1990. Species composition, distribution and invertebrate prey of fish assemblages in the Columbia River Estuary. Progress in Oceanography 25: 243-270.

Bower, J. L. 2009. Changes in marine bird abundance in the Salish Sea: 1975 to 2007. Marine Ornithology 37:9–17.

Breuning-Madsen, H., Ehlers-Koch, C., Gregersen, J., and C. L. Løjtnant. 2010. Influence of perennial colonies of piscivorous birds on soil nutrient contents in a temperate humid climate. Danish Journal of Geography 110(1): 25-35.

Brinker, D. F., J. M. McCann, B. Williams, and B. D. Watts. 2007. Colonial-nesting seabirds in the Chesapeake Bay region: where have we been and where are we going? Waterbirds 30(sp1):91-104.

BRNW (Bird Research Northwest). 2013a. Implementation and effects of double crested cormorant dissuasion research at East Sand Island, Columbia River Estuary: 2008-2012. Draft Technical Memorandum submitted to the U.S Army Corps of Engineers – Portland District, Portland, Oregon.

BRNW (Bird Research Northwest). 2013b. East Sand Island Biological Assessment: 2010-2012. Draft Technical Memorandum submitted to the U.S Army Corps of Engineers – Portland District, Portland, Oregon.

Bruskotter, J. T., Vaske, J. J., Schmidt, R. H., 2009. Social and cognitive correlates of Utah resident's acceptance of the lethal control of wolves. Human Dimensions Wildlife 14,119–132.

Carney, K. M. and W. J. Sydeman. 1999. A review of human disturbance effects on nesting colonial waterbirds. Waterbird Society 22: 68-79.

Carter, H. R., A. L. Sowls, M. S. Rodway, U. W. Wilson, R. W. Lowe, G. J. McChesney, F. Gress, and D. W. Anderson. 1995. Population size, trends, and conservation problems of the double-crested cormorants on the Pacific coast of North America. Colonial Waterbirds 18:189-215.

CEQ (Council on Environmental Quality). 2011a. Federal agency climate change adaptation planning: Implementing instructions. 4 March 2011. President's Council on Environmental Quality, Office of the White House, Washington, DC. http://www.whitehouse.gov/sites/default/files/microsites/ceq/adaptation_final_implementing_instructions_3_3.pdf.

CEQ (Council on Environmental Quality). 2011b. Federal agency climate change adaptation planning: Support Document. 4 March 2011. President's Council on Environmental Quality, Office of the White House, Washington, DC. http://www.whitehouse.gov/sites/default/files/microsites/ceq/adaptation_support_document_3_3.pdf.

CEQ (Council on Environmental Quality). 2013a. Principles and requirements for Federal investments in water resources. Chapters I and II. Final Draft, March 2013. President's Council on Environmental Quality, Office of the White House, Washington, DC. http://www.whitehouse.gov/administration/eop/ceq/initiatives/PandG.

CEQ (Council on Environmental Quality). 2013b. Interagency guidelines for Federal investments in water resources. Chapter III. Draft, March 2013. President's Council on Environmental Quality, Office of the White House, Washington, DC. http://www.whitehouse.gov/administration/eop/ceq/initiatives/PandG.

Chatwin, T. A., M. H. Mather, and T. D. Giesbrecht. 2002. Changes in pelagic and double-crested nesting populations in the Strait of Georgia, British Columbia. Northwestern Naturalist (Vancouver) 83:109-117.

Chaves, F. P., J. Ryan, S. E. Lluch-Cota, and M. Niquen. 2003. From anchovies to sardines and back: multidecadal change in the Pacific Ocean. Science 299: 217-221.

Clark, A. C., T. M. Kollasch, and D. A. Williamson. 2006. Movements of double-crested cormorants fledged on the Columbia River Estuary. Northwestern Naturalist 87:150-152.

Clements, S. T. Stahl, and C.B. Schreck. 2012. A comparison of the behavior and survival of coho salmon (*Onchorhynchus kisutch*) and steelhead trout (*O. mykiss*) in a small estuary system. Aquaculture 362-363:148-157.

Collis, K. D., D. D. Roby, D. P. Craig, B. A. Ryan, and R. D. Ledgerwood. 2001. Colonial waterbird predation on juvenile salmonids tagged with passive integrated transponders in the Columbia River Estuary: vulnerability of different salmonid species, stocks, and rearing types. Trans. Am. Fish. Soc., 130:385-396.

Collis, K., D. D. Roby, D. P. Craig, S. Adamany, J. Adkins, and D. E. Lyons. 2002. Colony size and diet composition of piscivorous waterbirds on the lower Columbia River: Implications for losses of juvenile salmonids to avian predation. Transactions of the American Fisheries Society 131:537–550.

Collis, K., D. D. Roby, K. W. Larson, L. J. Adrean, K. Nelson, A. F. Evans, D. Battaglia, D. E. Lyons, T. Marcella, and A. Patterson. 2012. Trends in Caspian tern nesting and diet in San Francisco Bay: Conservation implications for terns and salmonids. Waterbirds 35:25-34.

Coleman, A. M, H. L. Diefenderfer, D. L. Ward, and A. B. Borde. 2014. A Spatially Based Area-Time Inundation Index Model for Tidal Wetlands and Restoration Sites of the Lower Columbia River Floodplain and Estuary, Environmental Modelling and Software, in review.

COSEWIC. 2008. COSEWIC assessment and update status report on the Great Blue Heron fannini subspecies Ardea herodias fannini in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 39 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

Courtot, K. N., D. D. Roby, J. Y. Adkins, D. E. Lyons, D. T. King, and R. S. Larsen. 2012. Colony Connectivity of Pacific Coast Double-Crested Cormorants Based on Post-Breeding Dispersal from the Region's Largest Colony. Journal of Wildlife Management 76:1462–1471.

Cowardin, L. M., V. Carter, F. C. Golet and E. T LaRoe. 1979. Classification of Wetlands and Deepwater Habitats of the United States. U.S. Department of the Interior, Fish and Wildlife Service. FWS/OBS-79/31. December 1979. Reprinted 1992.

Crewe, T., K. Barry, P. Davidson, and D. Lepage. 2012. Coastal waterbird population trends in the Strait of Georgia 1999–2011. Results from the first 12 years of the British Columbia Coastal Waterbird Survey. British Columbia Birds 22:8–35.

Crozier, L. G., A. P. Hendry, P. W. Lawson, T. P. Quinn, N. J. Mantua, J. Battin, R. G. Shaw, and R. B. Huey. 2008. Potential responses to climate change in organisms with complex life histories: evolution and plasticity in Pacific salmon. Evolutionary Applications 1:252-270.

Crozier, L. 2011. Literature review for 2010 citations for BIOP: Biological effects of climate change. In: Endangered Species Act Federal Columbia River Power System 2010 Annual ESA Progress Report: Section 2, Attachment 1. p. 148ff.

Cuthbert, F. J., L. R. Wires, and J. E. McKeranan. 2002. Potential impacts of nesting double-crested cormorants on great blue herons and black-crowned night-herons in the U.S. Great Lakes Region. Journal of Great Lakes Research 28(2): 145-154.

Darby, M. 2014. Cultural Resources Survey of East Sand Island, Clatsop County. Draft report submitted to the U.S. Army Corps of Engineers – Portland District, Portland, Oregon.

Decker, D. J., T. L. Brown, and W. F. Siemer. (2001). Human dimensions of wildlife management in North America. Bethesda, MD: The Wildlife Society.

Dey, D. B. 2012. Estimation of percentages for listed Pacific salmon and steelhead smolts arriving at various locations in the Columbia River Basin in 2011. National Marine Fisheries Service, Northwest Fisheries Science Center, March 6, 2012, memo to James H. Lecky.

Dias, E., P. Morais, M. Leopold, J. Campos, and C. Antunes. 2012. Natural born indicators: great cormorant *Phalacrocorax carbo* (Aves: Phalacrocoracidae) as monitors of river discharge influence on estuarine ichthyofauna.

Diefenderfer, H. L., A. M. Coleman, A. B. Borde, and I. A. Sinks. 2008. Hydraulic geometry and microtopography of tidal freshwater forested wetlands and implications for restoration, Columbia River, U.S.A. Ecohydrology and Hydrobiology 8:339-361. doi: 10.2478/v10104-009-0027-7.

Dorr, B. S., T. Aderman, P. H. Butchko, and S. C. Barras. 2010. Management effects on breeding and foraging numbers and movements of double-crested cormorants in the Les Cheneaux Islands, Lake Huron, Michigan. Journal of Great Lakes Research 36:224–331.

Duerr, A. E., T. M. Donovan, and D. E. Capen. 2007. Management-induced reproductive failure and breeding dispersal in double-crested cormorants on Lake Champlain. Journal of wildlife Management 71:2565-2574.

Ellison, L. N. and L. Cleary. 1978. Effects of human disturbance on breeding of Double-crested Cormorants. Auk 95:510-517.

Evans, A. F., N. J. Hostetter, D. D. Roby, K. Collis, D. E. Lyons, B. P. Sandford, and R. D. Ledgerwood. 2012. Systemwide evaluation of avian predation on juvenile salmonids from the Columbia River based on recoveries of Passive Integrated Transponder tags. Transactions of the American Fisheries Society 141:975-989.

FPC (Fish Passage Center). 2013. Fish passage center 2012 annual report. FPC of the Columbia Basin Fish and Wildlife Authority, BPA Project 1994-033-00, Portland, Oregon. Available: http://www.fpc.org/documents/annual_FPC_report/FPC%202012%20Annual%20Report-Final2.pdf.

FPC (Fish Passage Center). 2014. Fish Passage Center Adult Passage Date. Available on-line at www.fpc.org.

Fox, D. S., S. Bell, W. Nehlsen, and J. Damron. 1984. The Columbia River Estuary: Atlas of Physical and Biological Characteristics. Columbia River Estuary Data Development Program, Astoria, Oregon.

Fresh, K. L., E. Casillas, L. L. Johnson, and D. L. Bottom. 2005. Role of the estuary in the recovery of Columbia River basin salmon and steelhead: an evaluation of the effects of selected factors on salmonid population viability. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-69, 105 pp.

Galbraith H., R. Jones, R. Park, J. Clough, S. Herrod-Julius, B. Harrington, and G. Page. 2002. Global climate change and sea level rise: potential losses of intertidal habitat for shorebirds. Waterbirds 20(2): 173-183.

Gill, R. E., Jr., and L. R. Mewaldt. 1983. Pacific Coast Caspian terns: dynamics of an expanding population. Auk 100:369-381.

Gowing, D. J., and G. Spoor. 1998. United Kingdom Floodplains, eds. R. Bailey, P. Jose, and B. Sherwood, 185-196. Otley, United Kingdom, Westbury.

Green Banks LLC. 2014a. *Wetland Delineation Report, East Sand Island, Clatsop County, OR.* Prepared in cooperation with Allegiance Group LLC for U.S. Army Corps of Engineers, Portland District.

Green Banks LLC. 2014b. ORWAP Functional Assessment Memo for East Sand Island, Clatsop County, OR. Prepared in cooperation with Allegiance Group LLC for U.S. Army Corps of Engineers, Portland District.

Gremillet, D., D. Schmid, and B. Culik. 1995. Energy requirements of breeding great cormorants *Phalacrocorax carbo sinensis*. Mar Ecol Prog Ser 121:1–9.

Gremillit, D. and T. Boulinier. 2009. Spatial ecology and conservation of seabirds facing global climate change: a review. Marine Ecology Progress Series. 391: 121-137.

Gresh, T., J. A. Lichatowich, and P. Schoonmaker. 2000. An estimation of historic and current levels of salmon production in the Northeast Pacific ecosystem: evidence of a nutrient deficit in the freshwater systems of the Pacific Northwest. *Fisheries* 25(1): 15-21.

Gress, F., R. W. Risebrough, D. W. Anderson, L. F. Kiff and J. R. Jehl, Jr. 1973. Reproductive failures of double-crested cormorants in southern California and Baja California. Wilson Bulletin 85:197-208.

Groot, C. and L.Margolis (Eds.), 1991. Pacific Salmon Life Histories. UBC, Press, University of British Columbia, Vancouver, Canada.

Guillaumet, A., B. Dorr, G. Wang, and T. Doyle. 2014. The cumulative effects of management on the population dynamics of the Double-crested Cormorant *Phalacrocorax auritus* in the Great Lakes. Ibis 156:141-152.

Harnish, R. A., G. E. Johnson, G. A. McMichael, M. S. Hughes, and B. D. Ebberts. 2012. "Effect of Migration Pathway on Travel Time and Survival of Acoustic-Tagged Juvenile Salmonids in the Columbia River Estuary." Transactions of the American Fisheries Society 141:507–519.

Hatch, J. J. 1995. Changing populations of double-crested cormorants. Colonial Waterbirds 18:8-24.

Hatch, J. J, and D. V. Weseloh. 1999. Double-crested cormorant (*Phalacrocorax auritus*), the birds of North America online (A. Poole, Ed.). Ithaca, New York. Available at: http://bna.birds.cornell.edu/bna/species/441/articles/introduction.

Hobara, S., T. Osono, K. Koba, N. Tokuchi, S. Fujiwara, and K. Kameda. 2001. Forest floor quality and N transformations in a temperate forest affected by avian-derived N deposition. Water Air Soil Pollution 130: 679-684.

Hogg, E. H. and J. K. Morton. 1983. The effects of nesting gulls on the vegetation and soils of islands in the Great Lakes. Can. J. Biol. 61:3240-3254.

Hostetter, N. J., Evans, E. F, Roby, D. D., and K. Collis. 2012. Susceptibility of Juvenile Steelhead to Avian Predation: the Influence of Individual Fish Characteristics and River Conditions. Transactions of the American Fisheries Society 141:1586–1599.

IPCC (Intergovernmental Panel on Climate Change). 2001. The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change (J. T. Houghton, Y. Ding, D. J. Griggs, M. Noguer, P. J. van der Linden, X. Dai, K. Maskell, and C. A. Johnson, eds.). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. http://www.ipcc.ch/ipccreports/tar/wg1/index.htm.

IPCC (Intergovernmental Panel on Climate Change). 2007a. Climate Change 2007: The Physical Science Basis, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K. B. Averyt, M. Tignor, and H. L. Miller, eds.). Cambridge, United Kingdom, and New York, NY: Cambridge University Press. http://ipcc-wg1.ucar.edu/wg1/wg1-report.html.

IPCC (Intergovernmental Panel on Climate Change). 2007b. IPCC Fourth Assessment Report Annex 1: Glossary. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K. B. Averyt, M. Tignor, and H. L. Miller, eds.). Cambridge, United Kingdom and New York, NY: Cambridge University Press. http://ipccwg1.ucar.edu/wg1/Report/AR4WG1_Print_Annexes.pdf.

ISAB (Independent Scientific Advisory Board). 2007. Climate Change Impacts on Columbia River Basin Fish and Wildlife. ISAB 2007-2. May 11, 2007. Northwest Power and Conservation Council, Portland, Oregon.

Ishida, Akira. 1996. Changes of soil properties in the colonies of the common cormorant, *Phalacrocorax carbo*. Journal of Forest Research 1: 31-35.

Jay, D. A., K. Leffler, H. L. Diefenderfer, and A. B. Borde. In revision. Tidal-fluvial and estuarine processes in the lower Columbia River, I. Along-channel water level variations, Pacific Ocean to Bonneville Dam. Estuaries and Coasts.

Johnson, G. E., et al. 2011. Evaluation of Cumulative Ecosystem Response to Restoration Projects in the Lower Columbia River and Estuary. PNNL-20296, Pacific Northwest National Laboratory, Richland, WA.

Karl, T. R., J. M. Melillo, and T. C. Peterson (eds.). 2009. Global Climate Change Impacts on the United States. Cambridge University Press, Cambridge.

Keefer, M. L and C. A. Peery. 2008. A literature review relevant to juvenile fall Chinook salmon habitat use, migration behavior, and survival in the lower Snake River. A technical report for Contract W912EF-08-D-005. Available at: http://www.webpages.uidaho.edu/uiferl/pdf%20reports/UI%20Snake%20River%20Fall%20Chinook%20review%20_FINAL_.pdf.

King, D. T. 1996. Movements of Double-crested Cormorants among winter roosts in the delta region of Mississippi. Journal of Field Ornithology 67: 205-211.

Kuentzel, W. F., Capen, D. E., Richards, Z. L., Higgins, B. R. 2012 Attitude strength and social acceptability of cormorant control programs on Lake Champlain. Journal of the Great Lakes, 38, 141-149.

Kuiken, T. 1999. Review of Newcastle disease in double-crested cormorants. Waterbirds 22:333-347.

Kury, C. R. and M. Gochfeld. 1975. Human interference and gull predation in cormorant colonies. Biol. Conserv 8:23-34.

Kushlan, J. A., M. J. Steinkamp, K. C. Parsons, J. Capp, M. Acosta Cruz, M. Coulter, I. Davidson, L. Dickson, N. Edelson, R. Elliot, R. M. Erwin, S. Hatch, S. Kress, R. Milko, S. Miller, K. Mills, R. Paul, R. Phillips, J. E. Saliva, B. Sydeman, J. Trapp, J. Wheeler, and K. Wohl. 2002. Waterbird Conservation for the Americas: The North American Waterbird Conservation Plan, Version 1. Waterbird Conservation for the Americas, Washington, DC, USA, 78 pp.

Kushlan, J. A. 2012. A history of conserving colonial waterbirds in the United States. Waterbirds 35:608-625.

Lemmon, C. R., G. Bugbee, and G. R. Stephens. 1994. Tree damage by nesting double-crested cormorants in Connecticut. The Connecticut Warbler 14(1): 27-30.

Lewis, H. F. 1929. The natural history of the double-crested cormorant (Phalacrocorax auritus auritus (Lesson)). Ru-Mi-Lou Books, Ottawa, Ontario.

Lichatowich, J. 2001. Salmon without rivers: a history of the Pacific salmon crisis. Island Press, Washington, D.C.

Ligeza, S. and H. Smal. 2003. Accumulation of nutrients in soils affected by perennial colonies of piscivorous birds with reference to biogeochemical cycles of elements. Chemosphere 52(2003): 595-602.

Loeffler, W. E. 1996. Dietary overlap and its implications for coexistence in a recently established assemblage of nesting seabirds at the Bolsa Chica Ecological Reserve. M.S. Thesis. California State Univ. Fullerton.

Ludwig, J. P. and C. L. Summer. 1995. Final report of the SERE Group Ltd. study to: Model the population of Double-crested Cormorants in the Les Cheneaux region of Lake Huron, and to collect data relevant to fish species utilization by cormorants and other waterbirds from the northern Great Lakes. The SERE Group, Ltd., Eureka, MI.

Lyons, D. E. 2010. Bioenergetics-based predator-prey relationships between piscivorous birds and juvenile salmonids in the Columbia River Estuary. Ph.D. dissertation, Oregon State University, Corvallis, Oregon. 331pp. Available at: www.birdresearchnw.org.

Lyons, D. E., D. D. Roby, A. F. Evans, N. J. Hostetter, and K. Collis. 2014. Benefits to Columbia River anadromous salmonids from potential reductions in predation by double-crested cormorants nesting at the East Sand Island colony: A report to the U.S. Army Corps of Engineers Portland District. Bird Research Northwest. Available on-line at www.birdresearchnw.org.

Manfredo, M. J., 2008. Who cares about wildlife? Social Science Concepts for Exploring Human-Wildlife Relationships and Conservation Issues. Springer, New York.

Marsh, D. M., W. D. Muir, R. W. Zabel, and D. Elliot. 2011. Alternative barging strategies to improve survival of transported juvenile salmonids. Proceedings of the 2011 Anadromous Fish Evaluation Program Annual Review. U.S. Army Corps of Engineers, Walla Walla District. Nov. 28 – Dec. 1, 2011.

Marshall, D. B., M. G. Hunter, and A. L. Contreras. 2006. Birds of Oregon: A general reference. Oregon State University Press, Corvallis, Oregon. 640 pp.

Matier, P. and A. Ross. (2014, April 7). Caltrans scramble to lure cormorants to new Bay Bridge span. *San Francisco Gate.* Available at: http://www.sfgate.com/bayarea/matier-ross/article/Caltrans-scrambles-to-lure-cormorants-to-new-Bay-5381205.php.

McArthur, Lewis A. 1915 The Pacific Coast Survey of 1849 and 1850. Oregon Historical Quarterly, Portland, Oregon. The Ivy Press.

McGowan, J. A., D. R. Cayan, and L. M. Dorman. 1998. Climate-Ocean Variability and Ecosystem Response in the Northeast Pacific. Science. 281: 210-217.

McMichael, G. A., J. A. Vucelick, B. A. Ryan, L. Gilbreath, R. L. McComas, D. Elliot, T. Murray, L. Applegate, and C. McKibben. 2006. Alternative barging strategies to improve survival of transported juvenile salmonids 2005. PNWD-3702, Battelle Pacific Northwest Division, Richland, WA.

McMichael, G. A., R. A. Harnish, B. J. Bellgraph, J. A. Carter, K. D. Ham, P. S. Titzler, and M. S. Hughes. 2010. Migratory behavior and survival of juvenile salmonids in the lower Columbia River and estuary in 2009. Pacific Northwest National Laboratory, PNNL-19545, Richland, Washington. Available: jsats.pnl.gov/Results/Publications.aspx.

Mercer, D. M. 2008. Phylogeography and population genetic structure of double-crested cormorants (*Phalacrocorax auritus*). M.S. thesis, Oregon State University, Corvallis, Oregon.

Mercer, D. M., S. M. Haig, and D. D. Roby. 2013. Phylogeography and population genetic structure of double-crested cormorants (Phalacrocorax auritus). Conservation Genetics 14(4):823-836.

Miller, I. M., C. Shishido, L. Antrim, and C. E. Bowlby. 2013. Climate Change and the Olympic Coast National Marine Sanctuary: Interpreting Potential Futures. Marine Sanctuaries Conservation Series ONMS-13-01. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries, Silver Spring, MD. 238 pp.

Mizota, C. 2009. Temporal variations in the concentration and isotopic signature of ammonium- and nitrate-nitrogen in soils under breeding colony of black-tailed gulls (Larus crassirostris) on Kabushima Island, northeastern Japan. Applied Geochemistry 24(2009): 328-332.

Mott, D. F., J. F. Glahn, P. L. Smith, D. S. Reinhold, K. J. Bruce and C. A. Sloan. 1998. An evaluation of dispersing Double-crested Cormorants from winter roosts for reducing predation on catfish in Mississippi. Wildlife Society Bulletin 26: 584-591.

Moul, I. E. and M. B. Gebauer. 2002. Status of the double-crested cormorant in British Columbia. Wildlife Working Report WR-105:i-viii, 31 pp.

Naughton, M. B., D. S. Pitkin, R. W. Lowe, K. J. So, and C. S. Strong. 2007. Catalog of Oregon seabird colonies. U.S. Department of Interior, Fish and Wildlife Service, Biological Technical Publication FWS/BTP-R1009-2007, Washington, D.C.

NOAA (NOAA Fisheries). 2008. Consultation on Remand for Operation of the Federal Columbia River Power System, 11 Bureau of Reclamation Projects in the Columbia Basin and ESA Section 10(a)(I)(A) Permit for Juvenile Fish Transportation Program (Revised and reissued pursuant to court order, NWF v. NMFS, Civ. No. CV 01-640-RE [D. Oregon]). National Marine Fisheries Service, Northwest Region 137 pp.

NOAA (NOAA Fisheries). 2010. Supplemental Consultation on Remand for Operation of the Federal Columbia River Power System, 11 Bureau of Reclamation Projects in the Columbia Basin and ESA Section 10(a)(I)(A) Permit for Juvenile Fish Transportation Program. National Marine Fisheries Service, Northwest Region 246 pp.

NOAA (NOAA Fisheries). 2011a. 5-Year Salmon and Steelhead ESA Status Reviews. National Marine Fisheries Service, Northwest Region. Portland, Oregon. Available at: http://www.westcoast.fisheries.noaa.gov/publications/status_reviews/salmon_steelhead/salmon_steelhead_esa_status_reviews.html.

NOAA (NOAA Fisheries). 2011b. Endangered and threatened species; designation of critical habitat for southern distinct population segment of eulachon. Federal Register. Available at: https://www.federalregister.gov/articles/2011/10/20/2011-26950/endangered-and-threatened-species-designation-of-critical-habitat-for-the-southern-distinct.

NOAA (NOAA Fisheries). 2012. Biological Opinion for the Reinitiation of Columbia River Navigation Channel Operations and Maintenance Mouth of the Columbia River to Bonneville Dam, Oregon and Washington. NFMS Consultation Number 2011/02095, Northwest Region 196 pp.

NOAA (NOAA Fisheries). 2013. Endangered and threatened species; designation of critical habitat for yelloweye rockfish, canary rockfish, and bocaccio of the Puget Sound/Georgia Basin. Federal Register. Available at: https://www.federalregister.gov/articles/2013/08/06/2013-18832/endangered-and-threatened-species-designation-of-critical-habitat-for-yelloweye-rockfish-canary.

NOAA (NOAA Fisheries). 2014. Supplemental Consultation on Remand for Operation of the Federal Columbia River Power System, 11 Bureau of Reclamation Projects in the Columbia Basin and ESA Section 10(a)(I)(A) Permit for Juvenile Fish Transportation Program. National Marine Fisheries Service, Northwest Region 246 pp.

NOAA (NOAA Fisheries). 2014(a). Office of Protected Resources. Overview of Endangered Species Act Listed Marine and Anadromous Fish. Available at: http://www.nmfs.noaa.gov/pr/species/fish/.

North American Bird Conservation Initiative, U.S. Committee. 2012. North American Bird Conservation Initiative – United States. Advancing Integrated Bird Conservation in North America. http://www.nabci-us.org.

NRC (National Research Council). 1987. Responding to Changes in Sea Level: Engineering Implications. Committee on Engineering Implications of Changes in Relative Mean Sea Level, Marine Board, National Research Council. National Academies Press, Washington, DC. ISBN: 0-309-59575-4, 160 pp.

NRC (National Research Council). 2012. Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present and Future. National Academies Press, Washington, DC. ISBN: 978-0-309-25594-3, 201 pp.

NRDC (Natural Resources Defense Council). 2014 Environmental News Media Center Press Release http://www.nrdc.org/media/2014/140211.asp.

OCCRI (Oregon Climate Change Research Institute). 2010. Oregon Climate Assessment Report. K.D. Dello and P.W. Mote (eds). College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis, OR. Available at: www.occri.net/OCAR.

Ontario Parks. 2008. Presqu'ile Cormorant Management Strategy Assessment 2003-2006. Ontario Ministry of Natural Resources. Peterborough, Ontario. 68 pp.

Opperman, H. 2003. A birder's guide to Washington. American Birding Association, Inc. Colorado Springs, Colorado.

Oregon Department of State Lands. 2010. P. Adamus, J. Morlan, and K. Verble. Manual for the Oregon Rapid Assessment Protocol (ORWAP), Version 2.0.2.

Pacific Biodiversity Institute. 2008. Bald Eagle species profile for Washington, Oregon, and Idaho. Accessed at: http://www.pacificbio.org/initiatives/ESIN/Birds/BaldEagle/baldeaglepg.html.

Pacific Flyway Council (PFC). 2012. Pacific Flyway Plan: A Framework for the Management of Double-crested Cormorant Depredation on Fish Resources in the Pacific Flyway. Pacific Flyway Council, U.S. Fish and Wildlife Service, Portland, Oregon. 55 pp.

Pacific Flyway Council. 2012a. Pacific Flyway Plan: A Framework for the Management of American White Pelican Depredation on Fish Resources in the Pacific Flyway. Pacific Flyway Council, U.S. Fish and Wildlife Service, Portland, Oregon. 49 pp.

Pacific Flyway Council (PFC). 2013. A Monitoring Strategy for the Western Population of Double-crested Cormorants within the Pacific Flyway. Pacific Flyway Council, U.S. Fish and Wildlife Service, Portland, Oregon. 37pp.

Palmer, R. S., ed. 1962. Handbook of North American birds, Vol. 1. Yale University Press, New Haven, CT.

Parkhurst, J. A., R. P. Brooks and D. E. Arnold. 1987. A survey of wildlife depredations and control techniques at fish-rearing facilities. Wildl. Soc. Bull. 15:386-394.

Parris, A., P. Bromirski, V. Burkett, D. Cayan, M. Culver, J. Hall, R. Horton, K. Knuuti, R. Moss, J. Obeysekera, A. Sallenger, and J. Weiss. 2012. Global Sea Level Rise Scenarios for the US National Climate Assessment. NOAA Tech Memo OAR CPO-1. 37 pp.

Pearson, S. F., and B. Altman. 2005. Range-wide Streaked Horned Lark (*Eremophila Alpestris strigata*) Assessment and Preliminary Conservation Strategy. Washington Department of Fish and Wildlife, Olympia, WA. 25pp.

Pearson, S. F., M. Hopey, W. D. Robinson, and R. Moore. 2005. Range, Abundance and Movement Patterns of Wintering Streaked Horned Larks (*Eremophila alpestris strigata*) in Oregon and Washington. Natural Areas Program Report 2005-2. Olympia, WA. 13 pp.

Pearson, S. F., P. J. Hodum, T. P. Good, M. Schrimpf, and S. Knapp. 2013. A model approach for estimating colony size, trends, and habitat associations of burrow-nesting seabirds. Condor 115(2):356-365.

Petersen, J. H., and J. F. Kitchell. 2001. Climate regimes and water temperature changes in the Columbia River: Bioenergetic implications for predators of juvenile salmon. Canadian Journal of Fisheries and Aquatic Sciences, 58:1831–1841.

Peterson, W. and F. Schwing. 2008. California Current Ecosystem. In Climate Impacts on U.S. Living Marine Resources: National Marine Fisheries Service Concerns, Activities and Needs. Edited by K. E. Osgood. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-F/SPO-89. Available at http://spo.nmfs.noaa.gov/tm/TM%20SPO%2089.pdf (Accessed February 2014).

Pevey, K. C., G. Savant, H. R. Moritz, and E. O. Childs. 2012. Draft Letter Report: Lower Columbia River Adaptive Hydraulics (AdH) Model. ERDC/CERL TR-XX-DRAFT, May 2012. USACE Construction Engineering Research Laboratory, Vicksburg, Mississippi.

R Development Core Team. 2008. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0. Available at: http://www.R-project.org.

Roby, D. D., K. Collis, D. E. Lyons, J. Y. Adkins, Y. Suzuki, P. Loschl, T. Lawes, K. Bixler, A. Peck-Richardson, E. Dykstra, J. Harms, W. Mashburn, J. Tennyson, N. Ventolini, A. Evans, B. Cramer, M. Hawbecker, N. Hostetter, R. Ledgerwood, and S. Sebring. 2012. Research, monitoring, and evaluation of avian predation on Salmonid smolts in the Lower and Mid-Columbia River. Draft 2011 annual report. Bird Research Northwest. Available on-line at www.birdresearchnw.org.

Roby, D. D., K. Collis, and 22 co-authors. 2013. Research, monitoring and evaluation of avian predation on salmonid smolts in the lower and mid-Columbia River. Final 2012 Annual Report to the Bonneville Power Administration and the U.S. Army Corp of Engineers. 103 pp plus figures and tables.

Roby, D. D., K. Collis, and 27 co-authors. 2014. Research, monitoring and evaluation of avian predation on salmonid smolts in the lower and mid-Columbia River. Draft 2013 Annual Report to the Bonneville Power Administration and the U.S. Army Corp of Engineers. 102 pp plus figures and tables.

Runge, M. C., W. L. Kendall, J. D. Nichols. 2004. Exploitation. Pages 303–328 in Sutherland W. J., I. Newton, and R. E. Green, eds. Bird Ecology and Conservation: A Handbook of Techniques. Oxford University Press, Oxford, UK.

Runge, M. C., J. R. Sauer, M. L. Avery, B. F. Blackwell, and M. D. Koneff. 2009. Assessing allowable take of migratory birds. Journal of Wildlife Management 73(4):556–565.

Rush, S. A., S. Verkoeyen, T. Dobbie, S. Dobbyn, C. E. Herbert, J. Gagnon, and A. T. Fisk. 2011. Influence of increasing populations of double-crested cormorants on soil nutrient characteristics of nesting islands in western Lake Erie. Journal of Great Lakes Research. 37(2011): 305-309.

Russell, I., B. Broughton, T. Keller, and D. N. Carss. 2012. The INTERCAFE Cormorant Management Toolbox— Methods for reducing Cormorant problems at European fisheries. COST Action 635 Final Report III, ISBN 978-1-906698-09-6.

Sauer, J. R., J. E. Hines, J. E. Fallon, K. L. Pardieck, D. J. Ziolkowski, Jr., and W. A. Link. 2011. *The North American Breeding Bird Survey, Results and Analysis 1966–2009. Version 3.23.2011.* USGS Patuxent Wildlife Research Center, Laurel, Maryland.

Savant, G. and T. O. McAlpin. 2014. Tidal hydrodynamics in the lower Columbia River Estuary through depth averaged adaptive hydraulics modeling. Journal of Engineering. Article ID 416914. http://dx.doi.org/10.1155/2014/416914.

Seattle Audubon Society. 2005. Brown pelican. BirdWeb: Seattle Audubon's online guide to the birds of Washington State. Available at: http://www.birdweb.org/birdweb/bird_details.aspx?value=search&id=34.

Sebring, S. H., M. C. Carper, R. D. Ledgerwood, B. P. Sandford, G. M. Matthews, and A. F. Evans. 2013. Relative vulnerability of PIT-tagged subyearling fall Chinook salmon to predation by Caspian terns and double-crested cormorants in the Columbia River Estuary. Transactions of the American Fisheries Society 142:1321-1334.

Shuford, W. D. and T. Gardali, ed. 2008. California Bird Species of Special Concern: A ranked assessment of species, subspecies, and distinct populations of birds of immediate conservation concern in California. Studies of Western Birds 1. Western Field Ornithologists, Camarillo, California, and California Department of Fish and Game, Sacramento.

Shuford, W. D. 2010. Inland-breeding pelicans, cormorants, gulls, and terns in California: A catalogue, digital atlas, and conservation tool. Wildlife Branch, Nongame Wildlife Program Report 2010-01. California Department of Fish and Game, Sacramento. Available at: www.dfg.ca.gov/wildlife/nongame/waterbirdcatalogue.

Siegel-Causey, D. and G. L. Hunt. 1981. Colonial defense behavior in double-crested and pelagic cormorants. Auk 98:522-531.

Slade, N. A., R. Gomulkiewicz, and H. M. Alexander. 1998. Alternatives to Robinson and Redford's Method of assessing overharvest from incomplete demographic data. Conservation Biology 12:148–155.

Steinkamp, M., B. Peterjohn, V. Byrd, H. Carter, and R. Lowe. 2003. Breeding season survey techniques for seabirds and colonial waterbirds throughout North America. Waterbird Monitoring Partnership of the Waterbirds for Americas Initiative. Available at: http://www.waterbirdconservation.org/pubs/PSGManual03.PDF.

Strickland, B., B. Dorr, F. Pogmore, G. Nohrenberg, S. Barras, J. McConnell, and J. Gobeille. 2011. Effect of management on Double-crested Cormorant nesting fidelity. Journal of Wildlife Management 75:1012-1021.

Stinson, D. W., J. W. Watson, and K. R. McAllister. 2007. Washington state status report for the bald eagle. Washington Department of Fish and Wildlife, Olympia, Washington. 86 pp.

Sullivan, K. L., P. D. Curtis, R. B. Chipman, and R. D. McCullough. 2006. The Double-crested Cormorant: Issues and Management. Cornell University Cooperative Extension. Dept. of

Nat. Res., Fernow Hall, Cornell University. Available at: http://wildlifecontrol.info/pubs/Documents/Cormorant/Cormorant.pdf.

Suzuki, Y. 2012 Piscivorous Colonial Waterbirds in the Columbia River Estuary: Demography, Dietary Contaminants and Management. Unpublished M.S. thesis, Oregon State University, Corvallis, Oregon.

Sydeman, W. J., M. M. Hester, J. A. Thayer, F. Gress, P. Martin, and J. Buffa. 2001. Climate change, reproductive performance and diet composition of marine birds in the southern California Current system, 1969-1997. Progress in Oceanography. 49: 309-329.

Tebaldi, C., B. H. Strauss, and C. E. Zervas. 2012. Modeling sea level rise impacts on storm surges along US coasts. *Environmental Research Letters* 7(2012): 014032. doi:10.1088/1748-9326/7/1/014032.

Tessler, D. F., J. A. Johnson, B. A. Andres, S. Thomas, and R. B. Lanctot. 2010. Black Oystercatcher (*Haematopus bachmani*) Conservation Action Plan. Version 1.1. International Black Oystercatcher Working Group, Alaska Department of Fish and Game, Anchorage, Alaska, U.S. Fish and Wildlife Service, Anchorage, Alaska, and Manomet Center for Conservation Sciences, Manomet, Massachusetts. 115 pp.

Thomas, D. W. 1983. Changes in the Columbia River Estuary habitat types over the past century. Report of the Columbia River Estuary Data Development Program. Columbia River Estuary Study Taskforce, Astoria, Oregon.

Thompson, D. R. and K. C. Hamer. 2000. Stress in seabirds: causes, consequences and diagnostic value. Journal of Aquatic Ecosystem Stress and Recovery. 7:91-110.

Tillmann, P., and D. Siemann. 2011. Climate change effects and adaptation approaches in marine and coastal ecosystems of the North Pacific Landscape Conservation Cooperative region - a compilation of scientific literature. Phase 1 Draft Final Report. National Wildlife Federation. Available at: http://northpacificlcc.org/documents/NPLCC_Marine_Climate%20Effects_Draft%20Fina.pdf.

Tobin, M. E., D. T. King, B. S. Dorr, S. J. Werner, and D. S. Reinhold. 2002. Effect of Roost Harassment on Cormorant Movements and Roosting in the Delta Region of Mississippi. Waterbirds 25(1):44-51.

TRG (The Research Group, LLC). 2014. Economic Effects and Social Implications Section for the Double Crested Cormorant Management Plan to Reduce Predation of Juvenile Salmonids in the Columbia River Estuary. Version 2.1. Submitted to the U.S Army Corps of Engineers – Portland District, Portland, Oregon. May 2014.

Tyson, L. A., J. L. Belant, F. J. Cuthbert, and D. V. Weseloh. 1997. Nesting populations of double-crested cormorants in the United States and Canada. Pages 17-25 In Symposium on Double-crested Cormorants: Population Status and Management Issues in the Midwest. USDA-APHIS Tech. Bull. No. 1879.

USACE (U.S. Army Corps of Engineers). 2009. Engineering Circular: Incorporating sea-level change considerations in Civil Works programs. EC 1165-2-211. 1 July 2009. U.S. Army Corps of Engineers, Washington, DC.

USACE (U.S. Army Corps of Engineers). 2010. Merged Light Detection and Ranging (LiDAR) and Bathymetry Dataset for the Lower Columbia River and Estuary. United States Army Corps of Engineers, Portland District, Portland, Oregon.

USACE (U.S. Army Corps of Engineers). 2011a. USACE Climate Change Adaptation Policy Statement. 3 June 2011. Office of the Assistant Secretary of the Army for Civil Works, Washington, DC. http://www.corpsclimate.us/docs/USACEAdaptationPolicy3June2011.pdf.

USACE (U.S. Army Corps of Engineers). 2011b. EC 1165-2-212. Engineering Circular: Sea-level change considerations for Civil Works programs. Updated 1 October 2011. Previously EC 1165-2-211, 1 July 2009. U.S. Army Corps of Engineers, Washington, DC. http://140.194.76.129/publications/eng-circulars/index.html.

USACE (U.S. Army Corps of Engineers). 2012. USACE 2012 Climate Change Adaptation Plan and Report. 23 June, 2012. https://corpsclimate.us/docs/2012_USACE_Adaptation_Plan_and_Report_23_June_2012%20final.pdf.

USACE (U.S. Army Corps of Engineers). 2013a. 2013 Strategic Sustainability Performance Plan. 28 June 2013. Office of the Assistant Secretary of the Army for Civil Works, Washington, DC. http://www.usace.army.mil/missions/sustainability/strategicsustainabilityperformanceplans.aspx.

USACE (U.S. Army Corps of Engineers). 2013b. ER 1100-2-8162. Engineering Regulation: Incorporating sea-level change in Civil Works programs. U.S. Army Corps of Engineers, Washington, DC. http://www.publications.usace.army.mil/Portals/76/Publications/EngineerRegulations/ER_1100-2-8162.pdf.

USACE (U.S. Army Corps of Engineers). 2013c. Columbia River LiDAR Project. CENWP, U.S. Army Corps of Engineers, Portland District, contract No. W9127N-10-D-0002 / 0001 and W9127N-09-D-0009 / 0006. Report and metadata available online: ftp://csc.noaa.gov/pub/DigitalCoast/lidar1_z/geoid12a/data/1122/supplemental/ColumbiaRiverLiDARProject_FinalSummaryReport.doc and http://csc.noaa.gov/dataviewer/webfiles/metadata/or2010_usace_columbia_river_template.html.

USACE (U.S. Army Corps of Engineers). 2013d. Mouth of the Columbia River South Jetty Dune Stabilization, Fort Stevens, Oregon. Interim-Final Design Documentation Report. April, 2013. Portland District, Portland, Oregon.

USDA-WS (U. S. Department of Agriculture, Wildlife Services). 1997, revised. Animal damage control program, final environmental impact statement. United States Department of Agriculture, Animal and Plant Health Inspection Service, Animal Damage Control [Wildlife Services], Operational Support Staff, Riverdale, Maryland, USA.

USDA-WS (U. S. Department of Agriculture, Wildlife Services). 2009. Final Environmental Assessment: Reducing Double-crested Cormorant Damage Management in Wisconsin. Available at: http://www.aphis.usda.gov/regulations/pdfs/nepa/WI%20DCCO%20EA%20Public%20Draft%20Final%20rev.pdf.

USDA-WS (U. S. Department of Agriculture, Wildlife Services). 2011a. Final Environmental Assessment: Bird Damage Management in Washington. Available at: http://www.aphis.usda.gov/regulations/pdfs/nepa.

USDA-WS (U. S. Department of Agriculture, Wildlife Services). 2011b. Final Environmental Assessment: Double-crested Cormorant Damage Management in Michigan. Available at: http://www.aphis.usda.gov/regulations/pdfs/nepa/MI_2011_Final_DCCO_EA.pdf.

USFWS (U. S. Fish and Wildlife Service). 2003. Final Environmental Impact Statement: Double-crested Cormorant Management. U.S. Fish and Wildlife Service, Division of Migratory Bird Management, Arlington, VA.

USFWS (U. S. Fish and Wildlife Service). 2005a. Caspian tern management to reduce predation of juvenile salmonids in the Columbia River Estuary, Final Environmental Impact Statement. Portland, OR.

USFWS (U. S. Fish and Wildlife Service). 2005b. Regional Seabird Conservation Plan, Pacific Region. U.S. Fish and Wildlife Service, Migratory Birds and Habitat Programs, Pacific Region, Portland, OR.

USFWS (U. S. Fish and Wildlife Service). 2008. Western Colonial Waterbird Survey Protocols. U.S. Fish and Wildlife Service, Portland, Oregon. Available at: http://www.fws.gov/mountain-prairie/species/birds/western_colonial/Phase%20I%20western%20waterbird%20protocols%2025%20Sept.pdf.

USFWS (U. S. Fish and Wildlife Service). 2009. Final Environmental Assessment: Extended Management of Double-crested Cormorants under 50 CFR 21.47 and 21.48. U.S. Dept. of the Interior, USFWS, Div. of Migratory Bird Management, 4401 N. Fairfax Drive MBSP-4017, Arlington, VA 22203.

USFWS (U. S. Fish and Wildlife Service). 2014. Draft Environmental Assessment: Management of Double-crested Cormorants under 50 CFR 21.47 and 21.48. U.S. Dept. of the Interior, USFWS, Div. of Migratory Bird Management, 4401 N. Fairfax Drive MBSP-4017, Arlington, VA 22203.

USFWS (U. S. Fish and Wildlife Service). 2014a. Species Profile and links, Bull Trout (Salvelinus confluentus). Available at: http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=E065#crithab.

USFWS (U. S. Fish and Wildlife Service). 2014b. Oregon Seabird Colony Catalog computer database and Colony Status Record archives. U.S. Fish and Wildlife Service, Oregon Coast National Wildlife Refuge Complex, Newport, Oregon 99567.

USGS (US Geological Survey). 2010. Wildlife Health Bulletin 2010-06. Available at http://www.nwhc.usgs.gov/publications/wildlife_health_bulletins/WHB_2010-06_Newcastle.pdf.

Van Der Veen, H. E. 1973. Some aspects of the breeding biology and demography of the Double-crested Cormorants (Phalacrocorax auritus) of Mandarte Island. Ph.D. thesis. Zoologisch Laboratorium der Rijksuniversiteit te Groningen, Groningen.

Wait, D. A., D. P. Aubrey, and W. B. Anderson. 2005. Seabird guano influences on desert islands: soil chemistry and herbaceous species richness and productivity. Journal of Arid Environments 60(2005): 681- 695.

Waterbird Conservation for the Americas. 2012. Waterbird Conservation for the Americas. http://www.waterbirdconservation.org.

Watson, W. J., M. G. Garrett, and R. G. Anthony. 1991. Foraging ecology of bald eagles in the Columbia River Estuary. Journal of Wildlife Management 55(3):492-499.

Watson, J. W., D. W. Stinson, K. R. McAllister, and T. E. Owens. 2002. Population status of bald eagles in Washington at the end of the 20th century. Journal of Raptor Research. 36:161-169.

WDFW (Washington Department of Fish and Wildlife). 2012. Candidate species 2012 annual report: Tufted Puffin. Available at: http://wdfw.wa.gov/conservation/endangered/species/tufted_puffin.pdf.

Weber, W. J. 1979. Health Hazards from pigeons, European starlings, and English sparrows. Thompson Publ. Fresno, Calif. 138 pp.

Weitkamp, L. A., P. J. Bentley, and M. Litz. 2012. Seasonal and interannual variation in juvenile salmonids and associated fish assemblage in open waters of the lower Columbia River Estuary. Fish. Bull. 110:426-450.

Weseloh, D. V. C. and P. J. Ewins. 1994. Characteristics of a rapidly increasing colony of double-crested cormorants (*Phalacrocorax auritus*) in Lake Ontario: Population size, reproductive parameters and band recoveries. Journal of Great Lakes Research 20(2): 443-456.

Whittaker, D., J. J. Vaske, M. J. Manfredo. 2006. Specificity and the cognitive hierarchy: Value orientations and the acceptability of urban wildlife management actions. Soc. Nat. Resour. 19, 515–530.

Williams, B. K., J. D. Nichols, and M. J. Conroy. 2001. Analysis and management of animal populations. Academic Press, San Diego, CA.

Wilson, U. W. 1991. Responses of three seabird species to El Niño events and other warm episodes on the Washington coast, 1979-1990. Condor 93:853-858.

Wires, L. R., F. J. Cuthbert, D. R. Trexel and A. R. Joshi. 2001. Status of the double-crested cormorant (*Phalacrocorax auritus*) in North America. Final Report to U.S. Fish and Wildlife Service.

Wires, L. R. and F. J. Cuthbert. 2006. Historic populations of the double-crested cormorant (*Phalacrocorax auritus*): Implications for conservation and management in the 21st century. Waterbirds 29:9-37.

Wright, S. K. 2005. Disturbance and roosting ecology of California brown pelicans (*Pelecanus occidentalis californicus*) on East Sand Island in the Columbia River Estuary. M.S. Thesis, Oregon State University, Corvallis, OR. 106 pp.

Wright, S. K., D. D. Roby, and R. G. Anthony. 2007. Responses of California brown pelicans to disturbances at large Oregon roost. Waterbirds 30:479-487.

Zamon, J. E., T. A. Cross, B. P. Sandford, A. F. Evans, and B. Cramer. 2013. Measuring estuary avian predation impacts on juvenile salmon by electronic recovery of ISO-PIT tags from bird colonies on East Sand Island, Oregon, 2012. Draft Report by Northwest Fisheries Science Center to the Portland District of U.S. Army Corps of Engineers.

Appendix B: Applicable Laws and Executive Orders

Law, Regulation, or Guideline	Description and Assessment of Compliance
Migratory Bird Treaty Act of 1918 (MBTA), as amended, (16 U.S.C. 703-711)	The MBTA implements treaties with other nations and imposed certain obligations on the U.S. for the conservation of migratory birds, including the responsibilities to: conserve and manage migratory birds internationally; sustain healthy migratory bird populations for consumptive and non-consumptive uses; and restore depleted populations of migratory birds. Conventions are also held with Mexico, Japan, and Russia. *USFWS is a cooperating agency to this EIS. Any action requiring permit under MBTA will be coordinated with USFWS.*
Endangered Species Act of 1973 (ESA), as amended (7 U.S.C. 136; 16 U.S.C.1531-1544)	It is Federal policy, under the ESA, that all Federal agencies seek to conserve threatened and endangered species and utilize their authorities in furtherance of the purposes of the Act (Sec. 2(c). *The alternatives in this EIS consider actions to implement Reasonable and Prudent Alternative Measures to support the 2008/2010FCRPS Biological Opinion under the ESA. The Corps coordinated with NOAA Fisheries on potential effects to ESA-listed anadromous fish species from the proposed management plan/action. The Corps and NOAA Fisheries agree the proposed actions in the preferred alternative of Phase I are adequately addressed in the FCRPS biological opinion and no Section 7 consultation is required for that Phase. A Biological Assessment (BA) will be prepared for the proposed terrain modification excavation and placement of dredged material on East Sand Island prior to implementing that Phase II action.* *A BA was developed to address all listed species in the project area under the jurisdiction of USFWS from the preferred management plan. The BA includes streaked horned larks and an assessment of potential effects to other listed species. The Corps' Channels and Harbors Program has completed consultation on the continued operation and maintenance dredging program for the Columbia River Federal Navigation Channel. Hazing Caspian terns and DCCOs on dredged material islands that are critical habitat for streaked horned larks occurs under this program. Consultation with the USFWS on the effects of the preferred management plan will be completed prior to implementation of Phase I.*
National Environmental Policy Act of 1969 (NEPA), as amended (42 U.S.C. 4321-4347)	NEPA requires Federal agencies to evaluate the potential environmental impacts when planning a major Federal action and ensures that environmental information is available to the public before decisions are made and actions are taken. *This EIS is the process for demonstrating compliance with NEPA.*
National Historic	Requires the effects of a "federal undertaking" to be assessed for their potential to affect

Law, Regulation, or Guideline	Description and Assessment of Compliance
Preservation Act (NHPA) of 1966 (16 USC 470(f))	historic properties on, or eligible for listing on the National Register of Historic Places, and to consult with the State Historic Preservation Officers. *Historic properties are identified in Chapter 3 effects to those properties are disclosed in Chapter 4. The Corps will be initiating consultation with SHPO prior to the final EIS.*
Coastal Zone Management Act (CZMA) of 1972, as amended (16 U.S.C. 1451-1464)	Protects environmental quality of coastal areas. *Early coordination with Oregon's CZMA Program concluded the best approach for determining consistency was to wait until the final EIS when the action will be more defined.*
Federal Water Pollution Control Act of 1948, as amended in 1972 as the Clean Water Act (CWA)	CWA contains a number of provisions to restore and maintain the quality of the nation's water resources. Provides for protection of water quality. Section 404 of the Clean Water Act (CWA) of 1977, as amended, requires that all projects involving the discharge of dredged or fill material into waters of the United States be evaluated for water quality and other effects prior to making the discharge. Federal regulations, at 33 CFR 336.1, provide that a Section 404 permit will not be issued for such fill material by the Corps to itself; however, the Corps shall apply the Section 404(b) (1) guidelines to the project. *See Section 404 evaluation on page 5.*
Bald and Golden Eagle Protection Act of 1940 (16 U.S.C. 668-668c)	This Act provides further protection for bald and golden eagles. The Act defines take as "to pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest or disturb." "Disturbance" relates to activities that affect the viability of eagle populations (e.g., from nest or chick abandonment), which would result from otherwise normal, lawful business practices. *Take as defined by the BGEPA would not occur as part of the proposed EIS alternatives. Although there could be some impacts to eagles from implementation of the alternatives, these impacts would be minor (flushing and potential to reduce foraging opportunities on the island which only makes up a small portion of the diet) these impacts would not result in "take" as defined by the Act.*
Executive Order 13186- Responsibilities of Federal Agencies to Protect Migratory Birds (January 10, 2001)	This Order identifies federal agency responsibilities to protect migratory birds and their habitats, and directs executive departments and agencies to undertake actions that will further implement the MBTA. The Order also directs federal agencies to develop a Memorandum of Understanding (MOU) with USFWS to promote the conservation of migratory bird populations, including their habitats, when their actions have, or are likely to have, a measurable negative effect on migratory bird populations. This Order also directs the Secretary of the Interior to establish The Council for the Conservation of Migratory Birds (Council) to oversee the implementation of this order. The Council serves to enhance coordination and communication among Federal agencies regarding their responsibilities under the four bilateral treaties on the conservation of

Law, Regulation, or Guideline	Description and Assessment of Compliance
	migratory birds. (Canada - 1916, Mexico - 1936, Japan - 1972, Russia - 1978) and also builds upon the progress that has been made in recent years on conservation of migratory birds. *The Department of Defense (DoD) signed an MOU with the USFWS, 31 July 2006, to comply with this executive order* *http://www.dodpif.org/plans/migratory/mbtadod.php* *The MOU is unclear about the applicability of the Civil Works program. The MOU states the DoD shall, among other things, "encourage incorporation of comprehensive migratory bird management objectives in the preparation of DoD planning documents (…including NEPA analyses)." The NEPA process allows for much of the coordination with USFWS and consideration of measures to minimize impacts to migratory birds where feasible. The USFWS established the Council in 2009.*
Executive Order 13175, Consultation and Coordination with Indian Tribal Governments	Provides a mechanism for establishing regular and meaningful consultation and collaboration with tribal officials in the development of Federal policies that have tribal implications. *The Corps sent out letters to tribes in the region initiating consultation soon after the Notice of Intent was published. Coordination with tribal governments has been ongoing through the regional programs and groups (SRWG, RIOG) that meet to discuss implementation of all FCRPS RPA's. The Confederate Tribes of the Colville Reservation replied to the Corp's request to accepting the invitation for government to government consultation and delegated staff to work with the Corps in development of the EIS.*
Executive Order 12898 (EO), Federal Actions to Address Environmental Justice in Minority and Low-Income Populations, 11 February 1994	The overall purpose of the order is to avoid disproportionately high imposition of any adverse environmental or economic impact on minority or low-income populations. All NEPA environmental analyses must include an evaluation of effects on minority and low income communities. *No subsistence, low-income or minority communities will be affected by the alternatives under consideration as none currently access or utilize East Sand Island. The alternatives under consideration will not cause disproportionately high and/or adverse effects on any minority or low-income populations and is compliant with the Order.*

Clean Water Act Section 404 Evaluation

Regulatory Authority

Section 404 of the Clean Water Act (CWA) of 1977, as amended, requires all activities involving the discharge of dredged or fill material into waters of the U.S. be evaluated for water quality and other effects prior to making the discharge. Federal regulations at 33 CFR 336.1 (a), provide that a Section 404 permit will not be issued for such fill material by the Corps to itself; however, the Corps shall applying all applicable substantive legal requirements, including public notice, opportunity for public hearing, and application of the Section 404 (b) (1) guidelines.

Under 33 CFR 230.13, the Corps applies Engineering Regulations (ER) 1105-2-11 in development of NEPA documents. ER 1105-2-100 C.6 (h) *Water Quality and Related Requirements* specifies the evaluation of the effects of the discharge of dredged or fill material, including consideration of the Section 404(b)(1) guidelines shall be included in the NEPA document where the plan or project involves the discharge of dredged or fill material into waters of the U.S. Full compliance with the CWA, and 404(b)(1) guidelines must be completed prior to the initiation of project construction (ER 1105-2-100 C.6 (e)).

In consideration of the Section 404(b)(1) guidelines, this evaluation assesses the effects of proposed terrain modification actions (described in Chapter 5) utilizing guidelines established by the EPA and described at 40 CFR 230 1-12 and in ER 1150-2-100, Appendix C. A public notice, describing the proposed action and fill under Section 404 has been issued for 45-day public review and comment. Coordination with other agencies has occurred (see Chapter 6).

Jurisdictional Waters of the U.S. on East Sand Island

The Corps' jurisdiction over tidal waters is outlined in Section 10 of the Rivers and Harbors Act and Section 404 of the Clean Water Act. Section 10 defines jurisdiction to the "mean high water line" which is the average of all high tides of navigable water ways. Section 404 defines jurisdiction to the "high tide line" which is the maximum height of a rising tide, not including storm surges (33 CFR 328.3(d)). Since the high tide line would be higher in elevation than the mean high water line, the high tide line was delineated to determine the federal jurisdictional limit.

Eight wetlands have been delineated on East Sand Island. Four are non-tidal freshwater wetlands with a mix of Cowardin classifications of palustrine scrub-shrub (PSS) and palustrine emergent (PEM). Four are tidal estuarine wetlands located entirely below the delineated tidal waters boundary. The Cowardin class of the tidal estuarine wetlands is estuarine emergent (EEM). No wetlands were identified on the western portion of the island where the proposed excavation of approximately 300,000 cubic yards of sand would occur. Placement of a portion of the approximately 30,000 cubic yards of rip rap material would occur below delineated high tide line and would constitute a fill under the CWA.

Project Description

The EIS describes the proposed action (Chapters 2 and 5), location and need for the action. In summary the terrain modification to East Sand Island would occur as part of long-term management plan and involve excavation of approximately 300,000 cubic yards of sand on the western most portion of East Sand Island (see Figure 2-4) to create inlet channels and lagoon type areas to inundate the island and preclude nesting by DCCOs in that location. To stabilize the island and ensure there would be no adverse effect to the Columbia River Federal Navigation Channel placement of approximately 30,000 cubic yards of rip rap would be placed on the northern shoreline.

Temporary impacts to waters of the U.S. could occur as a result of construction and staging activities. These impacts would be short in duration (construction activities and placement would occur during in-water work period Nov 15-Feb 15 in one season). Permanent impacts to waters of the U.S. would occur from the placement of rock armor below high tide line and potential disposal of excavated sand below high tide line and/or in wetlands on the eastern portion of the island. Disposal locations have not been fully identified and would be selected to minimize impacts where possible when confirmed as designs are finalized. Preference would be given to place material in upland areas and to supplement the designated Caspian tern colony area.

General Description of the Dredged Material

Due to the history of disturbance and the dynamic nature of the fluvial system, soils on the island are very young and poorly developed. Soils on East Sand Island are mapped in the Clatsop County, Oregon (OR007) Soil Survey as Tropopsamments, 0 to 15 percent slopes. Soils have been built up by repeated alluvial deposition, evidenced by the thin contrasting layers in exposed profiles from the northwestern shore of the island. They are very deep, excessively drained, and very low in organic matter and fines (silts and clays). Although guano from DCCO has accumulated on the western portion where excavation would occur, due to high porosity of sandy soils it is unlikely that any chemical contamination is present in the dredged material (see Section 4.2.1.)

Effects on the physical, chemical, and biological components of the aquatic environment

Physical substrate determinations.

Soils on East Sand Island are similar across the island and predominantly sandy with some silt and loam (see Section 3.2.1). Field personnel have noted the excrement of DCCO guano is toxic to the species of plants upon which DCCO nest on East Sand Island, and former nesting sites of DCCO on the island, where there was previously vegetation, are now bare of all vegetation and no longer used for nesting. Compaction is occurring on the Caspian tern colony where disposal would occur and disposal could affect the water table. However long-term disposal on the designated tern colony would provide benefits to nesting Caspian terns by creating more suitable habitat. East Sand Island is exposed to a high degree of wind and wave erosive forces and substantial amount of erosion has occurred and will likely continue. Soils observable in some beach exposures on the northern and northeastern shore of East Sand Island are higher in silt (predominantly silt loam textures). This is likely the Coquille soil in Map Unit 11A (Fluvaquentic Edoaquepts) that is mapped along the northern and eastern shores of adjacent Sand Island. This soil profile has common redox features throughout, as a result of its proximity to the water table and its higher water holding capacity. This inclusion may be capped with disposal of sand and occur as a buried soil further inland, likely perching and retaining water.

Water circulation, fluctuation, and salinity determinations.

East Sand Island is located near the mouth of the Columbia River and exposed to highly erosive wave action and wind. Placement of rock armor has been designed to stabilize the island and maintain current water circulation patterns. Disposal of excavated sand on the island and placement of rock armor would have little or no effect on water circulation or fluctuation, or salinity of the Columbia River and would maintain current conditions.

Suspended particulate/turbidity determinations.

The Mouth of the Columbia River is a high energy environment, with naturally occurring fluctuations of turbidity. Short-term turbidity increases are expected during disposal when this occurs near shoreline or below delineated high tide line. However, due to the high sand content of the disposal material, the dredged material is expected to settle out of the water column quickly and the turbidity plume resulting from the activity would be intermittent and temporary. In comparison to the natural fluctuations in the turbidity regime in the Mouth of the Columbia River, disposal-induced turbidity would be a minor contributor to the water column.

Contaminant determinations.

Disposal of excavated sand contains nutrients from DCCO guano. DCCO can contribute to higher levels of soil nitrogen, phosphorus, carbon, potassium and calcium (See section 4.21.). However, nutrient accumulation is likely less pronounced (or less persistent) in high-rainfall environments with sandy-textured soils, such as East Sand Island. Because sandy soils have a low water-holding capacity and high infiltration rate, rainwater mobilizes deposited guano and rapidly leaches it through the soil profile. In addition, sandy-textured soils that are low in organic matter have a low cation exchange capacity, so nutrients in solution are not retained on soil particle surfaces. Most nutrients and contaminants deposited in seabird guano likely have a short residence time in the soil profile before being flushed through and into the river system. Based on this there would be little to no effect from chemical contaminants to the Columbia River.

Aquatic ecosystem and organism determinations.
Adverse impacts of fill and discharge to the structure and function of the aquatic ecosystem and organisms are expected to be short term and minor. Some organisms could be buried or temporarily displaced by the fill below delineated high tide line. This work would be done in approved in-water work periods. Disposal could temporarily disrupt feeding and food sources of organisms present within the site. Aquatic ecosystem functions would essentially remain unchanged in the long term within the high-energy environment of the Mouth of the Columbia River.

The proposed terrain modification has the potential to provide additional direct and indirect beneficial effects for juvenile salmonids. The ability to create tidal wetlands to indirectly support juveniles through the production and export of macrodetritis and prey is possible. More intertidal mudflats and marsh areas could support shallow water rearing habitat for juveniles. Biological assessments are being prepared for consultation with USFWS and NOAA Fisheries to address the potential effects to listed threatened or endangered species and their critical habitat for the proposed action.

Proposed disposal site determinations.
Disposal sites on the island would be selected in upland locations wherever possible. Should disposal sites be located on the eastern portion of the island, it is possible that two delineated tidal estuarine wetlands, approximately 0.6 acre could be permanently filled. Potential mitigation for this impact could be enhancing other tidal estuarine wetlands present on the island or use of mitigation banks. Permanent disposal of materials in wetlands would be minimal. Temporary impacts to waters of the U.S. could occur during construction could affect wetlands. However, the area impacted would be relatively small and is unlikely to cause large-scale or long-term effects to aquatic habitat features in the Mouth of the Columbia River.

Determination of secondary and cumulative effects on the aquatic ecosystem.

Complete cumulative effects associated with the project are described in Chapter 4, Section 4.4. In summary, terrain modification would likely reduce overall nesting waterbird use of East Sand Island, but would benefit and increase usage of species that require marsh, mudflat, and inundated beach habitat. Species diversity on East Sand Island would likely increase. Less nutrient loading into the Columbia River Estuary would occur with decreased nesting waterbird abundance on East Sand Island. No change or adverse effect in the aquatic ecosystem from the cumulative placement of fill in nearshore environments along the Columbia River is expected. When combined with other disposal events in the Columbia River, disposal of sand on East Sand Island would likely mirror natural erosive processes. Because disposal of excavated sand is native material, no invasive material is being filled that would change the Mouth of the Columbia River's aquatic ecosystem.

Appendix C: Summary Tables of PIT Tag Predation Rates

TABLE C-1. Estimated Annual Consumption Numbers (95% confidence interval) of Juvenile Salmonid Smolts by Double-crested Cormorants Nesting on East Sand Island in the Columbia River Estuary during 1998-2013. Smolt consumption estimates are based on the percentage of salmonids (% salmonids) found in cormorant diet samples and bioenergetics modeling (see Methods).

	Consumption Estimates (millions)					% Salmonids (all species)	
Year	Yearling Chinook	Sub-yearling Chinook	Coho	Sockeye	Steelhead	April-Jun	April-July
1998	0.46 (0.15 - 0.77)	10.7 (4.7 - 16.7)	0.95 (0.33 - 1.57)	0.01 (0.00 - 0.03)	0.56 (0.21 - 0.90)	15%	12%
1999	0.94 (0.31 - 1.57)	8.56 (3.96 - 13.2)	1.75 (0.62 - 2.88)	0.03 (0.00 - 0.06)	1.09 (0.43 - 1.76)	28%	33%
2000	0.87 (0.32 - 1.42)	4.59 (2.13 - 7.04)	1.41 (0.59 - 2.23)	0.03 (0.00 - 0.06)	0.97 (0.42 - 1.51)	17%	21%
2001	0.43 (0.17 - 0.69)	5.00 (2.33 - 7.68)	0.82 (0.33 - 1.30)	0.01 (0.00 - 0.03)	0.52 (0.21 - 0.82)	9%	12%
2002	0.09 (0.01 - 0.16)	4.09 (1.73 - 6.46)	0.33 (0.06 - 0.61)	<0.01 (0.00 - 0.01)	0.12 (0.02 - 0.22)	5%	6%
2003	0.70 (0.23 - 1.17)	0.97 (0.44 - 1.51)	1.01 (0.37 - 1.64)	0.03 (0.00 - 0.05)	0.70 (0.25 - 1.15)	8%	10%
2004	0.51 (0.19 - 0.84)	5.21 (2.37 - 8.06)	1.00 (0.38 - 1.61)	0.02 (0.00 - 0.03)	0.60 (0.23 - 0.98)	6%	7%
2005	0.08 (0.03 - 0.13)	1.89 (0.81 - 2.98)	0.27 (0.11 - 0.42)	<0.01 (0.00 - 0.01)	0.17 (0.07 - 0.26)	2%	2%
2006	1.72 (0.67 - 2.77)	1.95 (0.87 - 3.03)	3.57 (1.43 - 5.70)	0.05 (0.00 - 0.10)	1.85 (0.78 - 2.93)	14%	19%
2007	1.09 (0.43 - 1.75)	4.07 (1.85 - 6.30)	2.66 (1.04 - 4.27)	0.02 (0.00 - 0.05)	1.31 (0.55 - 2.07)	11%	14%
2008	0.93 (0.68 - 1.18)	5.63 (3.71 - 7.54)	1.77 (1.33 - 2.21)	0.03 (0.01 - 0.05)	0.93 (0.72 - 1.14)	12%	15%
2009	0.67 (0.49 - 0.85)	8.26 (5.08 - 11.43)	1.40 (1.05 - 1.75)	0.02 (0.01 - 0.03)	0.80 (0.62 - 0.98)	9%	12%
2010	1.28 (0.96 - 1.60)	13.4 (9.13 - 17.6)	3.00 (2.26 - 3.73)	0.03 (0.01 - 0.06)	1.53 (1.20 - 1.85)	17%	22%
2011	0.90 (0.67 - 1.12)	15.6 (10.6 - 20.7)	2.74 (2.07 - 3.41)	0.07 (0.02 - 0.12)	1.15 (0.92 - 1.38)	18%	22%
2012	1.48 (1.01 - 1.95)	10.8 (6.79 - 14.81)	4.78 (3.55 - 6.01)	0.11 (0.03 - 0.18)	1.69 (1.27 - 2.11)	20%	27%
2013	0.89 (0.64 - 1.15)	11.4 (6.95 – 15.90)	2.71 (2.02 – 3.40)	0.16 (0.05 - 0.27)	1.04 (0.78 - 1.29)	11%	14%

TABLE C-2. Estimated Annual Predation Probabilities (95 percent credible interval) of ESA-listed PIT-tagged Salmonid Smolts by Double-crested Cormorants Nesting on East Sand Island in the Columbia River Estuary during 1999-2013. Predation probabilities are based on numbers of PIT-tagged fish interrogated (N) passing Bonneville Dam on the Columbia River or Sullivan Dam on the Willamette River subsequently consumed by cormorants. Only salmonid populations with > 500 PIT-tagged smolts interrogated passing a dam were evaluated in any given year. Dashes denote populations with < 500 fish available. Salmonid populations originating from the Snake River (SR), Upper Columbia River (UCR), Middle Columbia River (MCR) and Upper Willamette River (UWR) were evaluated, with runs of spring (Sp), summer (Su) and fall (Fa) fish included where applicable.

	ESU-specific Predation Probabilities							
Year	SR Sp/Su Chinook (Threatened)	SR Fa Chinook (Threatened)	UCR Sp Chinook (Endangered)	UWR Sp Chinook (Threatened)	SR Sockeye (Endangered)	MCR Steelhead (Threatened)	SR Steelhead (Threatened)	UCR Steelhead (Threatened)
1999	.009 (.006-.015) N=18558	.015 (.006-.030) N=1987	.007 (.002-.020) N=1325	-	-	.010 (.001-.035) N=632	.024 (.017-.039) N=12287	.020 (.013-.032) N=12123
2000	.033 (.023-.053) N=11810	.051 (.029-.093) N=1323	.034 (.016-.068) N=1123	-	-	-	.106 (.075-0.168) N=10356	.060 (.039-.100) N=3100
2001	.022 (.014-.035) N=8845	.055 (.029-.104) N=807	.033 (.017-.063) N=1230	-	-	.025 (.010-.057) N=872	.028 (.011-.061) N=774	-
2002	.018 (.013-.030) N=30617	.014 (.008-.026) N=4899	.022 (.016-.036) N=20493	-	-	-	.031 (.020-.051) N=7331	.037 (.014-.086) N=561
2003	.017 (.012-.027) N=28150	.011 (.007-.020) N=6234	.014 (.009-.021) N=30723	-	-	-	.019 (.012-.030) N=8553	.015 (.010-.024) N=27918
2004	.051 (.033-.085) N=4816	.019 (.006-.047) N=929	.047 (.032-.076) N=9533	-	-	-	.036 (.014-.080) N=803	.074 (.051-.118) N=6040
2005	.048 (.032-.079) N=5935	.036 (.018-.069) N=1121	.045 (.028-.078) N=2518	-	-	-	.043 (.020-.086) N=753	.055 (.037-.088) N=5610
2006	.052 (.035-.085) N=5570	.027 (.016-.046) N=4057	.047 (.022-.095) N=731	-	-	-	.131 (.082-.227) N=1100	.047 (.028-.082) N=2064
2007	.017 (.011-.027) N=23830	.016 (.007-.033) N=2005	.027 (.015-.051) N=2268	.010 (.003-.026) N=1505	-	.028 (.015-.052) N=2234	.035 (.023-.058) N=6391	.034 (.021-.061) N=3042
2008	.035 (.024-.055) N=11425	.026 (.019-.042) N=24136	.036 (.020-.066) N=1662	.033 (.019-.058) N=2509	-	.140 (.095-.232) N=2291	.147 (.106-.232) N=19572	.062 (.040-.104) N=2513
2009	.068 (.049-.107) N=17396	.045 (.032-.071) N=16314	.027 (.015-.049) N=2064	.014 (.008-.024) N=5573	.057 (.035-.098) N=1845	.149 (.103-.238) N=2700	.166 (.120-.257) N=23311	.072 (.047-.120) N=2265

ESU-specific Predation Probabilities								
Year	SR Sp/Su Chinook (Threatened)	SR Fa Chinook (Threatened)	UCR Sp Chinook (Endangered)	UWR Sp Chinook (Threatened)	SR Sockeye (Endangered)	MCR Steelhead (Threatened)	SR Steelhead (Threatened)	UCR Steelhead (Threatened)
2010	.053 (.039-.084) N=38441	.039 (.027-.061) N=17974	.033 (.023-.054) N=5972	.042 (.016-.092) N=510	.026 (.013-.049) N=1382	.082 (.058-.131) N=8515	.075 (.055-0.121) N=40024	.068 (.049-.106) N=12284
2011	.043 (.029-.069) N=6557	.019 (.013-.031) N=12327	.056 (.029-.108) N=704	.004 (.001-.015) N=1119	.048 (.024-.091) N=826	.078 (.046-.140) N=865	.053 (.037-.085) N=7028	.114 (.078-.186) N=2419
2012	.037 (.026-.060) N=17929	.026 (.018-.042) N=10742	.021 (.012-.037) N=3227	.006 (.003-.013) N=3731	.037 (.020-.069) N=1457	.033 (.017-.064) N=1084	.049 (.032-.081) N=4768	.065 (.043-.108) N=3357
2013	.036 (.025-.057) N=16167	.022 (.013-.037) N=4465	.030 (.018-.053) N=3112	.010 (.004-.020) N=2629	.033 (.018-.062) N=1454	.021 (.010-.041) N=1865	.025 (.017-.040) N=8516	.034 (.022-.057) N=4473

Appendix D: NOAA Fisheries per Capita Analysis

UNITED STATES DEPARTMENT OF COMMERCE National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
1201 NE Lloyd Boulevard, Suite 1100
Portland, OR 97232

December 9, 2013

MEMORANDUM FOR: Bruce Suzumoto and Ritchie Graves
FROM: Gary Fredricks
SUBJECT: Double-crested Cormorant Estuary Smolt Consumption BiOp Analysis

The primary goal for addressing double-crested cormorant (DCCO) smolt consumption in the 2013 BiOp is to determine the smolt survival "gap" that has resulted from the dramatic increase in cormorant population and smolt consumption between the base and current years that was not captured in the 2008 BiOp analysis.

Once the 2008 BiOp was completed it became apparent that the analysis did not completely address the full impact of rapidly increasing cormorant populations in the estuary on the current salmon ESU productivity estimates. The BiOp had to assess the likely effect of hydro/mitigation actions (i.e., continuing and future actions) on population/ESU productivity. The BiOp considers three periods of time.

- Base (roughly Brood Year 1981 to 2000 or Migration Year 1983 to 2002)
- Current (roughly Brood Year 2001 – 2006 or Migration Year 2003 to 2009)
- Prospective (2018 – after the implementation of all BiOp actions)

Base-to-Current and Current-to-Prospective multipliers were estimated for many factors (including Hydro) in order to estimate effects on listed stock productivity. "Current" estimates include all measured sources of mortality in the estuary and ocean attributable to birds, harvest, etc. Since the 2008 BiOp did not consider the dramatic estuary cormorant population increase in its analysis, the estimate of the current period productivity was somewhat less than it should have been. Because of this, a partitioning of this impact will be a negative multiplier. While this shortfall (or gap) can be addressed with any actions that improve productivity, it is logical that cormorant management objectives assist in this goal. This analysis calculates the size of the productivity gap for steelhead and yearling Chinook.

Sockeye are a special case in this analysis since this species was not included in the original 2008 BiOp Base to Current analysis, primarily due to a lack of information. In order to at least get an idea of the relative effect of cormorant predation on these fish, this analysis includes an estimate of consumption rate of sockeye compared to steelhead and yearling Chinook.

Analytical Approach

The gap analysis consists of a Microsoft Excel workbook that was completed primarily to calculate the negative multiplier for steelhead and yearling Chinook salmon. The analysis also uses a per capita (per bird) consumption level to calculate the number of cormorants that will likely need to be removed to zero the multiplier (fill the gap).

The analysis first presents the gap analysis for each species (steelhead and Chinook worksheet pages). The analysis uses annual cormorant species specific smolt consumption levels and the annual estimated estuary smolt population levels to calculate annual species specific smolt consumption rates. The resultant annual survival rates are then used to calculate average base and current period survival rates depending on what years are in the two periods. The average current period survival estimate divided by the average base period survival estimate provides the base-to-current survival estimate. The difference between this and 100 percent is considered as the base to current survival gap.

The key data sets for this analysis are the estimates of smolt consumption, estimates of cormorant population and estimates of smolt population.

Estuary double-crested cormorant smolt consumption estimates were based on bioenergetics modeling conducted by the avian researchers at Oregon State University and Real Time Research. Species-specific smolt consumption levels (numbers of smolt consumed) for the years 1998 to 2009 were provided by Collis (2010) and are presented in the data worksheet in the gap analysis. Consumption levels for 2010 through 2012 were found in the individual annual research reports for those years (Roby et al. 2011, 2012 and 2013). Consumption levels for years before 1998 were not available. Consumption and survival rates for these years were calculated based on the average current period consumption rates (approximately 2003-2009) adjusted for the cormorant population for the year or years in question and the area where those birds lived at that time. Birds nesting on Rice Island had a higher smolt consumption rate than birds nesting on East Sand Island. Collis et al. (2002) reported that cormorants nesting on Rice Island consumed approximately three times more salmon per bird than birds nesting on East Sand Island. No adjustment was made for the years 1980 through 1987 since birds were dispersed in the lower estuary (primarily Trestle Bay) during this time frame (Carter et al. 1995). The literature did provide Rice/East Sand population breakouts for the years 1988, 1991, 1992 and 1997 (Carter et al. 1995, Roby et al. 1998).

Estuary double-crested cormorant population estimates were determined for the years 1980 to2012, which encompasses all the base to current years. The early year population estimates were presented in the literature only for the years 1980, 1987, 1988, 1991-92 and 1997. The data were extended approximately equally between these years for years where no estimates exist. For example, the estimates for 1980 to 1994 were based on information provided by Carter et al 1995. The 1980 to 1987 rough estimate of <150 pairs was based on Carter's report of 262 birds nesting on structures in Trestle Bay and "other small colonies that may have been present" in 1980. The 1988 and 1989 estimate of 1,847 pairs was based on Carter's estimate of 3,694 individual birds in 1988. The 1990 to 1994 estimate of 3,364 pairs was based on an aggregate estimate from 1990 to 1992 of 6,728 birds surveyed in various locations in the Columbia River Estuary (Carter et al. 1995, Appendix 1). The 1995 to 1997 estimate of 6,104 pairs was based on Roby et al. 1998 (page 16). For the years 1998 through 2009, cormorant population estimates were provided in the western North America cormorant status assessment (Adkins et al. 2010).
For 2010 to 2012, the estimates were provided in the annual research reports (Roby et al. 2011, 2012, 2013).

All smolt population data (1998-2012) are from annual smolt population estimate memos issued by the NOAA Northwest Fisheries Science Center (Schiewe 1998 - 2002, Ferguson 2003-2010, Day 2011, Zabel 2012). Appendix 3 lists the specific data used for this analysis for each year. The species-specific population data were derived from the estimated smolt population arriving at Tongue Point in the estuary. These numbers are provided in the memos for full transport and spill with transport scenarios, thus the conditions that occurred for the year in question had to be determined before the best estimate was chosen.

A per capita consumption analysis was added to the gap analysis to determine how many cormorants might have to be removed from the estuary to achieve the steelhead survival levels that will eliminate the estimated negative productivity multiplier or gap. This analysis used the 1998 through 2012 cormorant consumption and population estimates to determine an average per capita consumption level for the East Sand Island cormorant colony. This fifteen year data set encompasses a fairly wide variation in cormorant salmonid consumption levels and river conditions and therefore likely serves as a decent predictor of per capita cormorant consumption rates in the near future, as long as the birds remain on or in the vicinity of East Sand Island. Also in support of this is the fact that East Sand Island cormorant population has remained fairly stable at about 10,500 to 13,500 pairs for the past ten years.

Analysis Results and Discussion

The results of the gap analysis indicate a 3.6 percent survival gap for steelhead exists between the average base period survival (migration years1983-2002) and the average current period survival (2003-2009). For yearling Chinook, a 1.1 percent gap exists between the base period survival (1982-2001) and current period survival (2002-2009). Table 1 presents the average survivals calculated by the analysis and the resultant gap for each species. The specific data used for each year are presented in Appendix 1.

Table 1. Results of the gap analysis (MY= Migration Year).	
Steelhead	
Ave Base Survival(MY1983-2002)	0.971
Ave Current Survival(MY2003-2009)	0.935
Current/Base	0.964
Base to Current Gap	0.036
Yearling Chinook	
Ave Base Survival(MY1982-2001)	0.988
Ave Current Survival(MY2002-2009)	0.978
Current/Base	0.989
Base to Current Gap	0.011

The results of the per capita analysis indicated a fifteen year average annual total consumption rate of 6.7 percent and 2.7 percent for steelhead and yearling Chinook, respectively, for a fifteen year average annual cormorant population of 10,378 pairs. These respective values for the current period were 6.5 percent and 2.5 percent for an average current period (for steelhead) cormorant population of 12,024 pairs. The base period consumption rate values were 2.9 percent and 1.2 percent for steelhead and Chinook, respectively. Since steelhead consumption rates are higher, a larger number of birds will need to be removed to achieve elimination of the negative multiplier or gap. Because of this, the steelhead portion of the analysis will likely drive the management actions. The per capita consumption rates for steelhead translate to a needed reduction of the cormorant colony size to a range of between 5,380 and 5,939 pairs in order to achieve the base (2.9 percent) consumption rate value. The range in the colony size reflects the average 95 percent confidence interval for the East Sand Island cormorant population estimates.

The results of the comparison of the fifteen year period average consumption rates for smolts of each salmonid species are presented in table 2. Sockeye were consumed at somewhat lower rates than either steelhead or yearling Chinook.

Table 2. Consumption rate comparison (average for 1998 – 2012).

Yearling Chinook	2.7%
Steelhead	6.7%
Sockeye	1.3%

A couple of issues have arisen regarding the application of these results. The issue of hatchery vs. wild susceptibility was investigated by Collis et al. (2001) and Ryan et al. (2003 and 2008). These investigators found through PIT tag analysis that, at least for steelhead, there was no consistent indication of a cormorant preference for prey based on rearing type. Another issue is the idea of compensatory predation mortality, which would argue that at least some portion of the fish consumed by predators would have died from other factors subsequent to the predation event. There is evidence that fish condition, size and rearing history may affect the vulnerability of fish to double-crested cormorant predation (Hostetter et al. 2012) and it is likely that predation losses to avian predators is compensated somewhat due to these vulnerabilities. This argument is not, however, particularly important to the treatment of cormorant predation in the supplemental BiOp. The analysis presented here considers only that double-crested cormorant population in the lower Columbia River Estuary has increased dramatically between the base and current periods. It is therefore, our assumption that the vulnerabilities are likely equal on both sides of the base and current periods in the analysis. The ultimate difference between these two periods is still the difference in the effect the increase in cormorant population has had on the populations of listed salmon. As an example for steelhead, if we assume that compensation is 50 percent and this was applied to the analysis equally during both periods, the resulting difference would be half of the calculated 3.6 percent, or 1.8 percent. However, the number of cormorants that would need to be reduced to get back to the base period consumption rate will still be between 5,380 and 5,939 pairs.

Literature Cited:

Adkins, J. Y. and D. D. Roby. 2010. A status assessment of the double-crested cormorant (Phalacrocorax auritus) in western North America: 1998-2009. Final Report to U. S. Army Corps of Engineers, Portland District. 59 pp. plus appendices.

Carter, H. R., A. L. Sowls, M. S. Rodway, U. W. Wilson, R. W. Lowe, G. J. McChesney, F. Gress, and D. W. Anderson. 1995. Population size, trends, and conservation problems of the double-crested cormorant on the Pacific Coast of North America. In: Nettleship DN, Duffy DC, editors. The double-crested cormorant: biology, conservation and management. Colonial Waterbirds 18 (Special Publication 1). p 189–207.

Collis, K. D., D. D. Roby, D. P. Craig, B. A. Ryan, and R. D. Ledgerwood. 2001. Colonial waterbird predation on juvenile salmonids tagged with passive integrated transponders in the Columbia River Estuary: vulnerability of different salmonid species, stocks, and rearing types. Trans. Am. Fish. Soc., 130:385-396.

Collis, 2002 Colony size and diet composition of piscivorous waterbirds on the lower Columbia River: implications for losses of juvenile salmonids to avian predation. Trans Am. Fish. Soc. 131:537-550.

Collis, K. 2010. Email (Subject: RE: Cormorant Consumption Data) to Gary.Fredricks@noaa.gov dated 3/30/10.

Dey, D. B. 2012. Estimation of percentages for listed Pacific salmon and steelhead smolts arriving at various locations in the Columbia River Basin in 2011. National Marine Fisheries Service, Northwest Fisheries Science Center, March 6, 2012, memo to James H. Lecky.

Ferguson, J. W. 2010. Estimation of percentages for listed Pacific salmon and steelhead smolts arriving at various locations in the Columbia River Basin in 2010. National Marine Fisheries Service, Northwest Fisheries Science Center, November 9, 2010, memo to James H. Lecky.

Ferguson, J. W. 2009. Estimation of percentages for listed Pacific salmon and steelhead smolts arriving at various locations in the Columbia River Basin in 2009. National Marine Fisheries Service, Northwest Fisheries Science Center, October 15, 2009, memo to James H. Lecky.

Ferguson, J. W. 2008. Final estimation of percentages for listed Pacific salmon and steelhead smolts arriving at various locations in the Columbia River Basin in 2008. National Marine Fisheries Service, Northwest Fisheries Science Center, December 4, 2008, memo to James H. Lecky.

Ferguson, J. W. 2007. Revised estimation of percentages for listed Pacific salmon and steelhead smolts arriving at various locations in the Columbia River Basin in 2007. National Marine Fisheries Service, Northwest Fisheries Science Center, September 11, 2007, memo to James H. Lecky.

Ferguson, J. W. 2006. Estimation of percentages for listed Pacific salmon and steelhead smolts arriving at various locations in the Columbia River Basin in 2006. National Marine

Fisheries Service, Northwest Fisheries Science Center, April 10, 2006, memo to James H. Lecky.

Ferguson, J. W. 2005. Revised estimation of percentages for listed Pacific salmon and steelhead smolts arriving at various locations in the Columbia River Basin in 2005 based on June 2005 changes in listing status. National Marine Fisheries Service, Northwest Fisheries Science Center August 24, 2005, memo to James H. Lecky.

Ferguson, J. W. 2004. Estimation of percentages for listed Pacific salmon and steelhead smolts arriving at various locations in the Columbia River Basin in 2004. National Marine Fisheries Service, Northwest Fisheries Science Center, March 29, 2004, memo to Laurie Allen.

Ferguson, J. W. 2003. Estimation of percentages for listed Pacific salmon and steelhead smolts arriving at various locations in the Columbia River Basin in 2003. National Marine Fisheries Service, Northwest Fisheries Science Center, March 20, 2003, memo to Laurie Allen.

Hostetter, N. J., A. F Evans, D. D. Roby and K. Collis. 2012. Susceptibility of juvenile steelhead to avian predation: the influence of individual fish characteristics and river conditions. Trans. Am. Fish. Soc. 141:1586-1599.

Marsh, D. 2013. March 12, 2013 email to Gary Fredricks. 1998 steelhead population estimates. Roby, D. D., and 19 co-authors. 2012. Research, monitoring and evaluation of avian predation on salmonid smolts in the lower and mid-Columbia River. Final 2011 Annual Report to the Bonneville Power Administration and the U.S. Army Corp of Engineers. 88 pp plus figures and tables.

Roby, D. D. and 20 co-authors. 2011. Research, monitoring and evaluation of avian predation on salmonid smolts in the lower and mid-Columbia River. Final 2010 Final Report to the Bonneville Power Administration and the U.S. Army Corp of Engineers. 81 pp plus figures and tables.

Roby, D. D., K. Collis and 22 co-authors. 2013. Research, monitoring and evaluation of avian predation on salmonid smolts in the lower and mid-Columbia River. DRAFT 2012 Annual Report to the Bonneville Power Administration and the U.S. Army Corp of Engineers. 103 pp plus figures and tables.

Roby, D. D., D. P. Craig, K. Collis, and S. L. Adamany. 1998 Avian predation on juvenile salmonids in the lower Columbia River. 1997 Annual Report to the Bonneville Power Administration and the U. S. Army Corps of Engineers. 32 pp plus figures and tables.

Ryan, B. A., S. G. Smith, J. M. Butzerin, and J. W. Ferguson. 2003. Relative vulnerability to avian predation of juvenile salmonids tagged with passive integrated transponders in the Columbia River Estuary, 1998-2000. Trans. Am. Fish. Soc. 132:275-288.

Appendix 1. Gap analysis tables.

Table 1. Estuary Cormorant Consumption - Steelhead

Year	Cormorant Population (pairs)	Sthd Consumption (Millions)	Sthd Population (Millions)	Consumption Rate	Survival Rate
1980	150			0.001	0.999
1981	150			0.001	0.999
1982	150			0.001	0.999
1983	150			0.001	0.999
1084	150			0.001	0.999
1985	150			0.001	0.999
1986	150			0.001	0.999
1987	150			0.001	0.999
1988	1847			0.017	0.983
1989	1847			0.017	0.983
1990	3364			0.031	0.969
1991	3364			0.031	0.969
1992	3364			0.031	0.969
1993	3364			0.031	0.969
1994	3364			0.031	0.969
1995	6104			0.045	0.955
1996	6104			0.045	0.955
1997	6104			0.045	0.955
1998	6285	0.817	13.0	0.063	0.937
1999	6561	1.092	13.9	0.079	0.921
2000	7162	0.966	14.0	0.069	0.931
2001	8120	0.516	14.9	0.035	0.965
2002	10230	0.119	13.9	0.009	0.991
2003	10646	0.701	14.5	0.048	0.952
2004	12480	0.605	13.7	0.044	0.956
2005	12287	0.166	13.7	0.012	0.988
2006	13738	1.855	14.3	0.130	0.870
2007	13771	1.311	13.9	0.094	0.906
2008	10950	0.931	14.1	0.066	0.934
2009	12087	0.796	13.8	0.058	0.942
2010	13596	1.500	14.1	0.106	0.894
2011	13045	1.200	15.7	0.076	0.924

2012	12300	1.700	14.3	0.119	0.881

Table 2. Estuary Cormorant Consumption - Yearling Chinook

Year	Cormorant Population (pairs)	YrCH Consumption (Millions)	YrCH Population (Millions)	Consumption Rate	Survival Rate
1980	150			0.000	1.000
1981	150			0.000	1.000
1982	150			0.000	1.000
1983	150			0.000	1.000
1084	150			0.000	1.000
1985	150			0.000	1.000
1986	150			0.000	1.000
1987	150			0.000	1.000
1988	1847			0.006	0.994
1989	1847			0.006	0.994
1990	3364			0.011	0.989
1991	3364			0.011	0.989
1992	3364			0.011	0.989
1993	3364			0.011	0.989
1994	3364			0.011	0.989
1995	6104			0.016	0.984
1996	6104			0.016	0.984
1997	6104			0.016	0.984
1998	6285	0.687	18.4	0.037	0.963
1999	6561	0.937	26.9	0.035	0.965
2000	7162	0.874	30.6	0.029	0.971
2001	8120	0.430	23.7	0.018	0.982
2002	10230	0.089	34.3	0.003	0.997
2003	10646	0.704	36.9	0.019	0.981
2004	12480	0.515	33.8	0.015	0.985
2005	12287	0.080	38.5	0.002	0.998
2006	13738	1.723	38.8	0.044	0.956
2007	13771	1.091	28.7	0.038	0.962
2008	10950	0.934	29.5	0.032	0.968
2009	12087	0.668	26.9	0.025	0.975
2010	13596	1.300	37.5	0.035	0.965
2011	13045	0.900	32.8	0.027	0.973

2012	12300	1.500	33.5	0.045	0.955

Table 3. Per capita analysis for steelhead

Steelhead							
Per Capita consumption analysis to estimate a cormorant colony size (pairs) that would close the							
Year	% Consumption		DCCO Population (pairs)			Per Capita	
		<95%CI	Best	>95%CI	<95%CI	Best	>95%CI
1998	6.3%	5908	6285	6662	0.0000106	0.000010	0.000009
1999	7.9%	6167	6561	6955	0.0000128	0.000012	0.000011
2000	6.9%	6732	7162	7592	0.0000103	0.000009	0.000009
2001	3.5%	7633	8120	8607	0.0000045	0.000004	0.000004
2002	0.9%	9616	10230	10844	0.0000009	0.000000	0.000000
2003	4.8%	10007	10646	11285	0.0000048	0.000004	0.000004
2004	4.4%	11731	12480	13229	0.0000038	0.000003	0.000003
2005	1.2%	11550	12287	13024	0.0000011	0.000001	0.000000
2006	13.0%	12914	13738	14562	0.0000101	0.000009	0.000008
2007	9.4%	12945	13770	14597	0.0000073	0.000006	0.000006
2008	6.6%	10585	10950	11315	0.0000063	0.000006	0.000005
2009	5.8%	11929	12087	12245	0.0000048	0.000004	0.000004
2010	10.6%	13130	13596	14062	0.0000081	0.000007	0.000007
2011	7.6%	12781	13045	13309	0.0000060	0.000005	0.000005
2012	11.9%	12035	12300	12567	0.0000099	0.000009	0.000009
Average	6.7%	10378	10884	11390	0.000007	0.00000	0.00000
Ave "Current" (03-09)	6.5%	11666	12280	12894	0.000005	0.00000	0.00000
An average colony size (pairs) of:					5380	5661	5939
Would achieve the Base Period consumption rate of:						2.9%	

Table 4. Per capita analysis for yearling Chinook.

Yearling Chinook			
Per Capita consumption analysis to estimate a cormorant colony size (pairs) that would close the Base to Current gap in juvenile Yr Chinook survival.			
Columbia River Estuary			
Year	% Consumption	DCCO Population	Per Capita Consumption
1998	3.7%	6285	0.0000059
1999	3.5%	6561	0.0000053
2000	2.9%	7162	0.0000040
2001	1.8%	8120	0.0000022
2002	0.3%	10230	0.0000003
2003	1.9%	10646	0.0000018
2004	1.5%	12480	0.0000012
2005	0.2%	12287	0.0000002
2006	4.4%	13738	0.0000032
2007	3.8%	13771	0.0000028
2008	3.2%	10950	0.0000029
2009	2.5%	12087	0.0000021
2010	3.5%	13596	0.0000025
2011	2.7%	13045	0.0000021
2012	4.5%	12300	0.0000036
Average	2.7%	10884	0.000003
Need to reduce DCCO colony size by:			3965
To achieve a yearling Chinook consumption reduction of:			1.1%
Which would be a reduction in average colony size of:			36%
Or an allowable average colony size of:			6919

Appendix 2. Data sources for the Columbia River Estuary double-crested cormorant consumption rate analysis for the 2013 BiOp.

1980-1997 All data from Fredricks 2008 and 2010 BiOp memos.

1997 Cormorant population estimates and Rice Island vs. East Sand Island proportions from Roby et al 1998 (1997 Annual Report).

1998 Cormorant population estimates from Collis et al. 2000 (1998 Annual Report). Steelhead consumption rates from Collis 3/30/2010 email attachment: V3 98-09 Estuary DCCO Consumption.xls. Steelhead estuary population estimate from Doug Marsh 3/12/13 email – 98sthdest with LCR fish.xls.

1999 Cormorant population estimates from Adkins and Roby 2010. Steelhead consumption rates from Collis 3/30/2010 email attachment: V3 98-09 Estuary DCCO Consumption.xls. Steelhead estuary population estimate from Schiewe 3/3/99 Population estimate memo.

2000 Cormorant population estimates from Adkins and Roby 2010. Steelhead consumption rates from Collis 3/30/2010 email attachment: V3 98-09 Estuary DCCO Consumption.xls. Steelhead estuary population estimate from Schiewe 3/16/00 Population estimate memo.

2001 Cormorant population estimates from Adkins and Roby 2010. Steelhead consumption rates from Collis 3/30/2010 email attachment: V3 98-09 Estuary DCCO Consumption.xls. Steelhead estuary population estimate from Schiewe 5/2/01 Population estimate memo.

2002 Cormorant population estimates from Adkins and Roby 2010. Steelhead consumption rates from Collis 3/30/2010 email attachment: V3 98-09 Estuary DCCO Consumption.xls. Steelhead estuary population estimate from Schiewe 3/28/02 Population estimate memo.

2003 Cormorant population estimates from Adkins and Roby 2010. Steelhead consumption rates from Collis 3/30/2010 email attachment: V3 98-09 Estuary DCCO Consumption.xls. Steelhead estuary population estimate from Ferguson 3/20/03 Population estimate memo.

2004 Cormorant population estimates from Adkins and Roby 2010. Steelhead consumption rates from Collis 3/30/2010 email attachment: V3 98-09 Estuary DCCO Consumption.xls. Steelhead estuary population estimate from Ferguson 3/29/04 Population estimate memo.

2005 Cormorant population estimates from Adkins and Roby 2010. Steelhead consumption rates from Collis 3/30/2010 email attachment: V3 98-09 Estuary DCCO Consumption.xls. Steelhead estuary population estimate from Ferguson 8/24/05 Population estimate memo.

2006 Cormorant population estimates from Adkins and Roby 2010. Steelhead consumption rates from Collis 3/30/2010 email attachment: V3 98-09 Estuary DCCO Consumption.xls. Steelhead estuary population estimate from Ferguson 4/10/06 Population estimate memo.

2007 Cormorant population estimates from Adkins and Roby 2010. Steelhead consumption rates from Collis 3/30/2010 email attachment: V3 98-09 Estuary DCCO Consumption.xls. Steelhead estuary population estimate from Ferguson 9/11/07 Population estimate memo.

2008 Cormorant population estimates from Adkins and Roby 2010. Steelhead consumption rates from Collis 3/30/2010 email attachment: V3 98-09 Estuary DCCO Consumption.xls. Steelhead and Chinook estuary population estimate from Ferguson 12/4/08 Population estimate memo.

2009 Cormorant population estimates from Adkins and Roby 2010. Steelhead consumption rates from Collis 3/30/2010 email attachment: V3 98-09 Estuary DCCO Consumption.xls. Steelhead and Chinook estuary population estimate from Ferguson 10/15/09 Population estimate memo.

2010 Cormorant population estimates from Roby et al 2011 (2010 Annual Report). Steelhead consumption rates from Roby et al. 2011. Steelhead and Chinook estuary population estimate from Ferguson 11/9/10 Population estimate memo.

2011 Cormorant population estimates from Roby et al 2012 (2011 Annual Report). Steelhead and Chinook consumption rates also from Roby et al 2012. Steelhead and Chinook estuary population estimate from Dey 3/6/12 Population estimate memo.

2012 Cormorant population estimates from Roby et al. 2013 (Draft 2012 Annual Report). Steelhead consumption rates from Annual Report. Steelhead and Chinook estuary population estimate from Zabel 1/23/13 Population estimate memo.

Appendix 3. Smolt population data summary memo.

July 29, 2013 F/NWR-5

FILE MEMORANDUM
FROM: Gary Fredricks
SUBJECT: Smolt Population Estimates for Estuary Cormorant Consumption Analysis

The data for steelhead and yearling Chinook estuary (Tongue Point) population estimates for the double crested cormorant analysis came from the following NOAA Science Center memos and correspondence for each year from 1998 to 2012. These data were used to estimate consumption rates for these species of fish by cormorants feeding in the lower estuary. Since the consumption rates are total number of fish eaten by species, the population estimate has to be based on the total number of fish available (not just listed fish available).

1998 – Steelhead: 3/12/13 email from Doug Marsh No page number, Table 12. Added wild (813,901) and hatchery (12,173,677) estimates at Tongue Point for a total steelhead estimate of **12,987,578**. Yearling Chinook: Schiewe 1998, February 11, 1998. Table 5, full transport with spill scenario - **18,397,190**. Sockeye: Schiewe 1998, Table 5 with spill - **1,291,687**.

1999 – Schiewe 1999, March 3, 1999. Steelhead: Table 12, transport with spill. Added wild (983,624) and hatchery (12,865,635) estimates at Tongue Point for a total steelhead estimate of **13,849,259**. Yearling Chinook: Table 6, transport with spill. Added wild (2,059,807) and hatchery (24,816,940) estimates at Tongue Point for a total yearling Chinook estimate of **26,876,747**. Sockeye: Table 5, transport with spill **– 1,283,905**.

2000 - Schiewe 2000, March 16, 2000. Steelhead: Table 6, transport with spill. Added wild (1,792,916) and hatchery (12,184,824) estimates at Tongue Point for a total steelhead estimate of **13,977,740**. Yearling Chinook: Table 6, transport with spill. Added wild (8,733,906) and hatchery (21,831,929) estimates at Tongue Point for a total yearling Chinook estimate of **30,565,835**. Sub Chinook: Table 5, transport with spill **– 47,345104**. Sockeye: Table 5, transport with spill **– 3, 257, 494**.

2001 - Schiewe 2001, May 2, 2001. Steelhead: Table 9, Full transportation at Tongue Point - **14,923,748**. Yearling Chinook: Table 7, Full transportation at Tongue Point **– 23,704,323**. Sub Chinook: Same table **– 38,571,680**. Sockeye: Table 7, full transport **– 2,122,764**.

2002 - Schiewe 2002, March 28, 2002. Steelhead: Table 10, transport with spill. Added wild

(2,165,789) and hatchery (11,700,319) estimates at Tongue Point for a total steelhead estimate of **13,866,108**. Yearling Chinook: Table 8, transport with spill. Added wild (10,771,077) and hatchery (23,531,162) estimates at Tongue Point for a total yearling Chinook estimate of **34,302,239**. Sub Chinook: Table 7, transportation with spill **– 47,139,165**. Sockeye: Table 7, transport with spill **– 2,081,468**.

2003 - Ferguson 2003, March 20, 2003 memo. Steelhead: Table 10, Transportation with spill - Added wild (2,702,533) and hatchery (11,781,527) estimates at Tongue Point for a total steelhead estimate of **14,484,060**. Yearling Chinook: Table 8, transport with spill. Added wild (12,651,681) and hatchery (24,200,009) estimates at Tongue Point for a total yearling Chinook estimate of **36,851,690**. Sub Chinook: Table 7, full transportation **– 59,463,290**. Sockeye: Table 7, with spill **– 1,781,584**.

2004 - Ferguson 2004, March 29, 2004 memo. Steelhead: Table 10, Full transportation - Added wild (2,602,246) and hatchery (11,060,851) estimates at Tongue Point for a total steelhead estimate of **13,663,097**. Yearling Chinook: Table 8, full transportation - Added wild (12,142,606) and hatchery (21,683,696) estimates at Tongue Point for a total yearling Chinook estimate of **33,826,302**. Sub Chinook: Table 7, full transportation **– 60,475.322**. Sockeye: Table 7, full transport **- 1,850,321**.

2005 - Ferguson 2005, August 24, 2005 memo. Steelhead: page 45, Table 9, Full Transportation **-13,692,289**. Yearling Chinook: page 36, Table 7a, Full Transportation **– 38,509,029**. Sub Chinook: page 38, Table 7b (transport with spill) **– 81,247,508**. Sockeye: Table 7c, full transport **– 1,781,663**.

2006 - Ferguson 2006, April 10, 2006 memo. Steelhead: page 51, Table 9, Transportation with spill **-14,278,819**. Yearling Chinook: page 44, Table 7b, Transportation with spill **– 38,832,655**. Sub Chinook: same page and table **– 89,791,172**. Sockeye: Table 7c, with spill **– 1,368,440**.

2007 - Ferguson 2007, September 11, 2007 memo. Steelhead: page 52, Table 9, Transportation with spill **-13,922,277**. Yearling Chinook: page 45, Table 7b, Transportation with spill – **28,719,701**. Sub Chinook: same page and table **– 90,003,337**. Sockeye: Table 7c, with spill – **1,663,764**.

2008 - Ferguson 2008, December 4, 2008 memo. Steelhead: page 52, Table 9, Transportation with spill **-14,046,231**. Yearling Chinook: page 45, Table 7b, Transportation with spill **–** **29,538,756**. Sub Chinook: same page and table **– 81,940,043**. Sockeye: Table 7c, with spill **–** **1,650,027**.

2009 – Ferguson 2009, October 15, 2009 memo. Steelhead: page 53, Table 9, Transportation with spill **-13,800,640**. Yearling Chinook: page 46, Table 7b, Transportation with spill **– 26,902,885**. Sub Chinook: same page and table **– 87,612,607**. Sockeye: Table 7c, with spill **– 1,489,029**.

2010 – Ferguson 2010, November 9, 2010 memo. Steelhead: page 56, Table 9, Transportation with spill **-14,091,647**. Yearling Chinook: page 49, Table 7b, Transportation with spill **– 35,517,282**. Sub Chinook: same page and table **– 80,208,807**. Sockeye: Table 7c, with spill **– 1,492,268**.

2011 – Dey 2012, March 6, 2012 memo. Steelhead: page 56, Table 9, Transportation with spill **-15,706,982**. Yearling Chinook: page 49, Table 7b, Transportation with spill **– 32,807,329**. Sub Chinook: same page and table **– 88,555,553**. Sockeye: Table 7c, with spill **– 1,489,406**.

2012 – Zabel et al, January 23, 2013 memo. Steelhead: page 56, Table 9, Transportation with spill **-14,282,359**. Yearling Chinook: page 49, Table 7b, Transportation with spill **– 33,476,396**. Sub Chinook: same page and table **– 82,710,393**. Sockeye: Table 7c, with spill **– 1,657,481**.

Data from Ken Collis' spreadsheet: Copy of v3 98-09 estuary dcco consumption.xls (sheet: Consumption Data with 95 percent CI).																				
scenario	date of	model	total salmonids			chinook, sub-yearling			chinook, yearling			coho			sockeye			steelhead		
	estimate	revision	min	best	max	min	best	max	min	best	max	min	best	max	min	best	max	min	best	max
1998 Total	39304	3	7.972538	14.99552	22.01851	6.04632	12.11229	18.17826	0.345553	0.686643	1.027732	0.694745	1.35783	2.020914	0.006254	0.021446	0.036638	0.437698	0.817314	1.19693
1999 Total			5.914695	12.36584	18.81698	3.95545	8.556197	13.15694	0.305362	0.937002	1.568641	0.620176	1.750721	2.881266	-0.0002	0.030401	0.061003	0.425491	1.091518	1.757545
2000 Total			3.768665	7.862304	11.95594	2.130427	4.585188	7.039949	0.324045	0.87426	1.424474	0.586009	1.405932	2.225856	0.000866	0.031405	0.061944	0.418328	0.965519	1.51271
2001 ES	39304	3	3.241129	6.778788	10.31645	2.326869	5.003389	7.67991	0.16876	0.429913	0.691066	0.326893	0.815697	1.304501	0.000834	0.01398	0.027126	0.211946	0.515809	0.819672
2002 ES	39304	3	2.004261	4.637369	7.270477	1.727224	4.094756	6.462288	0.014227	0.089318	0.164408	0.060313	0.333841	0.607369	6.35E-06	0.000164	0.000322	0.01938	0.11929	0.2192
2003 ES	39304	3	1.532003	3.409985	5.287966	0.443927	0.974876	1.505824	0.23442	0.703683	1.172947	0.374034	1.005018	1.636002	-0.00028	0.025485	0.051248	0.254959	0.700922	1.146885
2004 ES	39304	3	3.496283	7.34712	11.19796	2.372198	5.214959	8.057721	0.188358	0.514915	0.841471	0.380753	0.996701	1.612649	0.001327	0.01591	0.030494	0.230124	0.604634	0.979144
2005 ES	39304	3	1.082384	2.408425	3.734466	0.81047	1.893767	2.977064	0.029429	0.079764	0.1301	0.109716	0.266637	0.423558	9.16E-05	0.001999	0.003906	0.070572	0.166258	0.261944
2006 ES	39304	3	4.060271	9.137534	14.2148	0.86507	1.945474	3.025877	0.672846	1.722527	2.772209	1.431976	3.566875	5.701773	-0.00413	0.047702	0.099538	0.776325	1.854957	2.933588
2007 ES	39414	3	4.302968	9.156402	14.00984	1.845794	4.073863	6.301932	0.431452	1.090545	1.749639	1.040227	2.65604	4.271853	0.002184	0.024908	0.047633	0.549902	1.311046	2.072189
2008 ES	40140	4	7.105007	9.289814	11.47462	3.713252	5.62834	7.543428	0.684605	0.933507	1.182409	1.33029	1.769495	2.2087	0.00976	0.027402	0.045044	0.72447	0.93107	1.13767
2009 ES	40140	4	7.740189	11.13764	14.5351	5.079365	8.256174	11.43298	0.489313	0.667771	0.846229	1.048515	1.397404	1.746294	0.005849	0.020302	0.034755	0.616623	0.795992	0.97536

Appendix E-1: Population Model to Assess Take Levels of the Western Population of Double-crested Cormorants and the Double-crested Cormorant Colony on East Sand Island

Josh Dooley. Wildlife Management Institute.*911 NE 11th Ave, Portland, OR 97232; josh_dooley@fws.gov; 503-231-2383

Michelle McDowell. U.S. Fish and Wildlife Service. 911 NE 11th Ave, Portland, OR 97232; Michelle_McDowell@fws.gov; 503-231-20244

*on U.S. Fish and Wildlife Service contract

INTRODUCTION

The U.S. Fish and Wildlife Service developed this population model to assist in assessing potential effects of different annual scenarios and rates of individual and egg take on the western population of double-crested cormorants (*Phalacrocorax auritus*, DCCO Western Population Model). In 2011 the Pacific Flyway Council (Council) identified the need to develop an approach to manage DCCOs, coordinated among the 12 western states comprising the flyway. In 2012 the Council developed *A Framework for the Management of Double-crested Cormorant Depredation on Fish Resources in the Pacific Flyway* (Framework; Pacific Flyway Council 2012) to assist managers in developing management strategies to address conflicts with DCCOs. The Framework identified priority management strategies, including the exploration of population modeling options to assess sustainable levels of take while ensuring the conservation of DCCOs. The Council then developed the *Potential Biological Removal (PBR) Model for Assessing Allowable Take Levels* (Dooley 2012). The DCCO Western Population Model was developed subsequent to the PBR model, extending to include density dependence, egg take, and calculating population growth as a function of recruitment and adult survival. The DCCO Western Population Model projects population levels through time (trajectories), and could be used to assess the effects of take levels on the western population of double-crested cormorants.

METHODS

The following model was used to estimate western population abundance trajectories (see Table E-1 1 for model input parameters):

(1) $$N_{t+1} = (N_t(1 - c_t)) * \left[1 + (1 - p_{t\_realized})(a + bN_t)\right] * S_{ASY}$$

where;

N_t	= number of breeding individuals at the beginning of year *t*,
c_t	= individual take rate in year *t,*
$p_{t\_realized}$	= realized nest/egg take rate in year *t*; (i.e., 20 % of take rate in year t_{-2}; 60% of take rate in year $t_{-3;}$ 20% of take rate in year t_{-4})
a	= annual recruitment rate (i.e., number of new breeding individuals),
b	= density dependence parameter, and
S_{ASY}	= annual survival rate of after-second-year (ASY) individuals

Further details of a similar modeling approach can be found in the Final Environmental Assessment to Extend Management of Double-crested Cormorants (USFWS 2009) and the Draft Environmental Assessment (USFWS 2014). The model is an extension of the Potential Biological Removal and Prescribed Take Level model (Wade 1998, Runge et al. 2004, 2009) and similar to the logistic growth model with harvest (Williams et al. 2002:140):

(2)

$$N_{t+1} = N_t + r_{max} N_t \left[1 - \frac{N_t}{K}\right] - h_t N_t$$

where,

K	= carrying capacity,
r_{max}	= maximum growth rate, and
h_t	= harvest rate

In equation 1, $r_{max,}$ has been replaced by its underlying components, namely adult survival and recruitment. Additionally, we incorporated the culling parameter within the first term of the equation, rather than at the end as in equation 2 because the majority of management activities (culling) would occur prior to or during the breeding season. Thus, our model is a pre-recruitment culling model (i.e., breeding individuals survive the post-recruitment to pre-recruitment interval, they arrive at the breeding grounds, culling occurs, then the population undergoes density dependent recruitment). Equation 2 is a post-recruitment culling model. A post-recruitment model is more applicable for species, such as waterfowl, where harvest occurs after the recruitment event (recruitment occurs in spring/summer; harvest occurs in fall/winter). In our model, the survival interval goes from post-recruitment to pre-recruitment the following year, and the recruitment event is instantaneous; thus, second-year breeding individuals are ASY post-recruitment and survive at ASY survival rates thereafter. We included a time lag effect for egg take, representative of the approximate proportion of new breeding individuals recruited into the population as 2nd, 3rd, and >3rd year breeders, as documented from past research (approximately 20 percent, 60 percent, and 20 percent annually in years 3, 4, and 5 if egg take occurred in year 1, see Table E-1 1). If the same level of egg take occurs over multiple years, the maximum, annual realized nest/egg take rate equals the initial egg take rate specified. Thus, for analysis presented in Figure E-1 1, we included nest/egg take as the maximum, annual realized nest/egg take value.

We used a 3-age model to calculate recruitment (*a*), which is the rate that new breeding individuals were produced in a given year.

(3)

$$a = \left[(S_{HY} * S_{SY} * SY_{\%b} * F) + \left(S_{HY} * S_{SY} * S_{ASY} * ASY_{3y\%b} * F\right) + \sum_{i=2}^{n} \left(S_{HY} * S_{SY} * S_{ASY}^{i} * ASY_{>3y\%b} * F\right) \right] * \left[(S_{HY} * S_{SY} * SY_{\%b}) + \left(S_{HY} * S_{SY} * S_{ASY} * (ASY_{3y\%b} - SY_{\%b})\right) + \left(S_{HY} * S_{SY} * S_{ASY}^{2} * (ASY_{>3y\%b} - ASY_{3y\%b})\right) \right]$$

where,

S_{HY} = survival of hatch year (HY) individuals,

S_{SY} = survival of second year (SY) individuals,

S_{ASY} = survival of after second year (ASY) individuals,

$SY_{\%b}$ = proportion of second year individuals that return to breed,

$ASY_{3y\%b}$ = proportion of after second year individuals that return to breed in year 3,

$ASY_{>3y\%b}$ = proportion of after second year individuals that return to breed in year >3,

F = number of fledglings produced per breeding individual,

n = number of years after second year individuals remain in population

F was calculated as:

(4)

$$F = \frac{E * H * S_C}{2}$$

where,

E = number of eggs per nests,

H = hatch rate of eggs, and

S_C = survival rate of chick to fledgling

To calculate recruitment we made the following assumptions: 1) survival differed by 3-age classes (HY, SY, and ASY) and maximum life expectancy of an individual remaining in the breeding population was 17 years; 2) the proportion of individuals that returned to breed differed by 3-age classes: individuals returning after their 2nd, 3rd, and >3rd year. We assumed that no individuals bred during their 1st year. Van der Veen (1973) reported that <5 percent of first year individuals bred on Mandarte Island, British Columbia. From preliminary banding data on East Sand Island, <0.1 percent of banded chicks were confirmed first year breeders (Y. Sazuki, OSU, unpubl. data.); 3) all individuals within an age class have the same parameter values; 4) all age classes have the same fledgling success; and 5) for nest/egg take in equation 1, nest/eggs taken directly correlates to take of density-dependent recruitment (i.e, *a* as a function of *b*; e.g., if 20 percent of eggs are taken, density-dependent recruitment is decreased by 20 percent). In this final assumption (5), we did not attempt to include potential compensatory or additive effects at life stages later than egg stage (i.e., chick and fledgling) in affecting recruitment because no data was available to model the direction or magnitude of this effect; thus, a direct relationship of nest/egg take to density-dependent recruitment was modeled.

To estimate the density dependence parameter (*b*), we adjusted *b* under a deterministic scenario (i.e., no variance) to find the value that projected the population, under no individual or nest/egg take, from an initial abundance to a final abundance (i.e., carrying capacity) within a given number of years. We then used the estimated *b* with a 10 percent coefficient of variation (CV) for simulations.

To estimate annual abundance using equation 1, we conducted a Monte Carlo simulation in Program R (R Development Core Team 2008). For each time period, we conducted 10,000 simulations. Parameters were randomly sampled from truncated normal distributions, using the parameter values, CV, and upper and lower truncation given in Appendix E-2, Table 1. Parameter values were based on literature and unpublished estimates. We used mean or most representative values and truncated values above/below expected ranges or if not possible (e.g., survival >1.0). We used the mean abundance from a given time period (N_t) to calculate abundance for the next time period (N_{t+1}). We calculated 95 percent lower- and upper- confidence limits (LCL and UCL) for annual abundance estimates using the 97.5 percent and 2.5 percent quantiles of the 10,000 simulations. For model output, we refer to year 1 as the initial abundance estimate, and, if take is to occur that year, the first year of management action. Year 2 is the next year's initial abundance (or, the ending abundance for year 1) after all annual mortality has occurred (likewise for subsequent years). As an example of this modeling approach, we evaluated the effect of annual individual take rates of 0–10 percent and annual nest take rates of 0–40 percent on the western population of DCCOs.

We conducted a sensitivity analysis to examine the influence that individual model input parameters had on population growth. We independently decreased each input parameter value by 10 percent to estimate the percentage change in lambda (N_{t1}/N_0). For adjusted input parameters, we used the same percent CV and adjusted the upper and lower truncation points by 10 percent.

Points of Discussion Concerning Model

Because DCCOs have delayed breeding, there is a time lag between when egg take occurs and when effects will be realized on recruitment (i.e., population growth). We modeled the realized effects of egg take equal to the approximate rate at which new 2nd, 3rd, and >3rd year individuals return to breed based upon past research (approximately 20 percent, 60 percent, and 20 percent annually in years 3, 4, and 5 if egg take occurred in year 1). We acknowledge that effects from egg take will not occur as simplistically as described; however, we felt this was the best approximation to capture the nest/egg take lag effect. In this analysis (see Figure E-1 1), we did not include a nest/egg lag effect, as we only included the maximum, annual realized nest/egg take value that would be observed (i.e., maximum realized value is the initial specified value if the same level of egg take occurs over multiple years). For this analysis, we were not looking at management actions starting at a given point in time, but rather the effect of continued, annual take.

Take levels should be considered within the context of the parameter values chosen. Carrying capacity, which is modeled with the density dependence parameter (*b*), largely influences how take will affect the population. As a population's carrying capacity cannot be empirically known, a choice has to be made about which carrying capacity estimate to use. Choice should be justified by data, to the extent possible, or a range of potential values should be used if there is uncertainty. Additionally, choice of initial population size will determine the level of take necessary to achieve a particular target size. Multiple year averages should be used when available, rather than extreme values, prior-year estimates, or single-year estimates, as they are more representative of the central tendency of the data.

Additional knowledge concerning factors affecting growth, response, and density dependence would improve the ability to model these dynamics. In a general sense, the density dependence parameter (*b*) models a proportionally changing relationship in regard to additive versus compensatory morality; the additional (i.e., additive) loss of an individual is more greatly compensated when abundance is further from carrying capacity (i.e., mortality is more compensatory) compared to when abundance is closer to carrying capacity (mortality is more additive). Additionally, the density-dependent parameter (*b*) can be thought of as general constraint on underlying growth (i.e., when abundance is close to carrying capacity, growth is nil). The input parameters pertaining to recruitment (i.e., number of eggs, fledglings, etc.) likely capture the growth potential of the species, but levels of intrinsic (i.e., recruitment) versus extrinsic (i.e., immigration) growth at a colony or within a given population cannot be distinguished from abundance data alone; thus, the modeled growth rate through density dependence includes both intrinsic and extrinsic growth. We modeled the effect of take of an individual as equal across sex and age and only considered breeding individuals. We did this because: 1) we wanted to take a generalized approach; 2) determination of age, sex, and breeding status in the field during culling is typically not possible; and 3) the data required to incorporate these additional factors into the model do not exist; for example, existing population abundance and growth data is based upon breeding individuals, and extrapolation to the non-breeding segment of the population is tenuous and would not change observed growth rates. Model performance would likely improve if the following parameters were appropriately monitored for the western population of DCCOs and then incorporated into the current model: compensatory versus additive mortality; density-dependent relationships among parameters; extrinsic versus intrinsic growth and differences between past and future growth potential; and ages, sex, and breeding status.

We believe that the input parameter values adequately describe the population growth potential of this species based on life history characteristics. Our recruitment estimate (*a*, see above) of 0.396 (0.280–0.513) was similar to other estimates for this species, which were calculated using different methodologies. For the Great Lakes DCCO population, an estimate of 0.471 (0.384–0.553) was reported (USFWS 2014, ancillary data). Maximum growth rate (r_{max}) of the Great Lakes DCCO population was reported as 1.235 (1.131–1.316) using the equation: S_{ASY}*(1+*a*). Using this equation, our maximum growth rate estimate was 1.187 (1.088–1.286). We also estimated maximum growth rate using Slade's method (Slade et al. 1998, Runge et al. 2004). Using this method, our point estimate for maximum growth rate was 1.200, which corresponds to a recruitment point estimate of 0.412.

From our sensitivity analysis, survival of ASY individuals had the greatest influence on lambda; approximately 3-times greater than survival of HY and SY individuals and 4-times greater than the proportion of ASY individuals returning to breed in year >3. The influence of other input parameters on lambda was negligible, changing lambda <3 percent on average (Table E-1 2). Our results agree with Blackwell et al. (2002) and Ludwig and Summer (1995), who also found that adult survival had the greatest effect on DCCO population growth. Multiple, independent studies have estimated survival of ASY individuals within a very narrow range (0.841–0.884; see Table E-2 1). We used 0.85 for the mean value in our simulations. Thus, we believe that our simulations were rather robust to uncertainty in input parameter values because the parameter that had the greatest influence on population growth had the least associated uncertainty. Survival of ASY individuals was likely modeled adequately in our simulations. Other input parameters had more uncertainty associated with them, but these parameters had much less influence on population growth.

Table E-1 1. Description, mean value, coefficient of variation (CV), and lower and upper truncation points (LTrunc/UTrunc) of parameters used in the DCCO western population model simulations.

Parameter	Description	Mean Value; CV; LTrunc/UTrunc	Reference
$N_{WP\_int\_future}$	Initial number of breeding individuals in the western population (ca. 2009) for modeling future abundance	58,480; 0.10; 55,556/61,404	[1]Adkins and Roby 2010
*a	recruitment parameter	0.396; 0.15; 0.25/0.55	USFWS 2014, ancillary data = 0.471 (0.384-0.553) Slade method = 0.412
b_{WP}	density dependence parameter to project western population from 41,660 breeding individuals in 1990 to final population size (carrying capacity) of 58,480 breeding individuals in 2009	-0.0000037244; 0.10; mean±0.50*mean	
S_{HY}	hatch year survival	0.4; 0.10; 0.25/0.55	Hatch and Wesoloh 1999 = 0.5 USFWS 2009 = 0.297 USFWS 2014, ancillary data = 0.446 Blackwell et al. 2002 = 0.30-0.35
S_{SY}	second year survival	0.75; 0.10; 0.65/0.85	Hatch and Wesoloh 1999 = 0.75 USFWS 2009 = 0.778 USFWS 2014, ancillary data = 0.835
S_{ASY}	after second year survival	0.85; 0.10; 0.80/0.90	Hatch and Wesoloh 1999 = 0.85 USFWS 2009 = 0.841 USFWS 2014, ancillary data = 0.884
$SY_{\%b}$	proportion of second year individuals that return to breed	0.17; 0.10; 0.02/0.32	Hatch and Wesoloh 1999; Van Der Veen 1973 = 0.17
$ASY_{3y\%b}$	proportion of after second years that return to breed in year 3	0.79; 0.10; 0.64/0.94	Hatch and Wesoloh 1999; Van Der Veen 1973 = 0.79
$ASY_{>3y\%b}$	proportion of after second years that return to breed in year >3	0.98; 0.10; 0.94/1.0	Hatch and Wesoloh 1999; Van Der Veen 1973 = 0.98
*F	number of year-end fledglings produced per breeding pair	2.08; 0.16; 1.5/2.5	Hatch and Weseloh 1999 = 1.2 to 2.4 (mean = 1.8) Blackwell et al. 2002 = 1.7-2.5 BRNW data = 2.08

Parameter	Description	Mean Value; CV; LTrunc/UTrunc	Reference
N	number of years after second years remain in population	15	Hatch and Weseloh 1999 = 6.1 mean life expectancy; oldest bird 17 yr)
E	number of eggs per breeding pair	3.85; 0.10; 3.25/4.45	Hatch and Weseloh (1999) = 2.7 to 4.1 (mean = 3.4; mode = 4) BRNW data = 3.85
H	hatch rate of eggs	0.8; 0.10; 0.60/1.0	Hatch and Weseloh (1999) = 0.5 to 0.7 (mean = 0.6) BRNW data = 0.8
S_c	survival rate of chick to fledgling	0.675; 0.10; 0.5/0.85	BRNW data = 0.675 (28day post-hatch survival = 0.75; 28day to fledgling survival = 0.90).

*Parameters were calculated using equations 3 and 4, respectively.

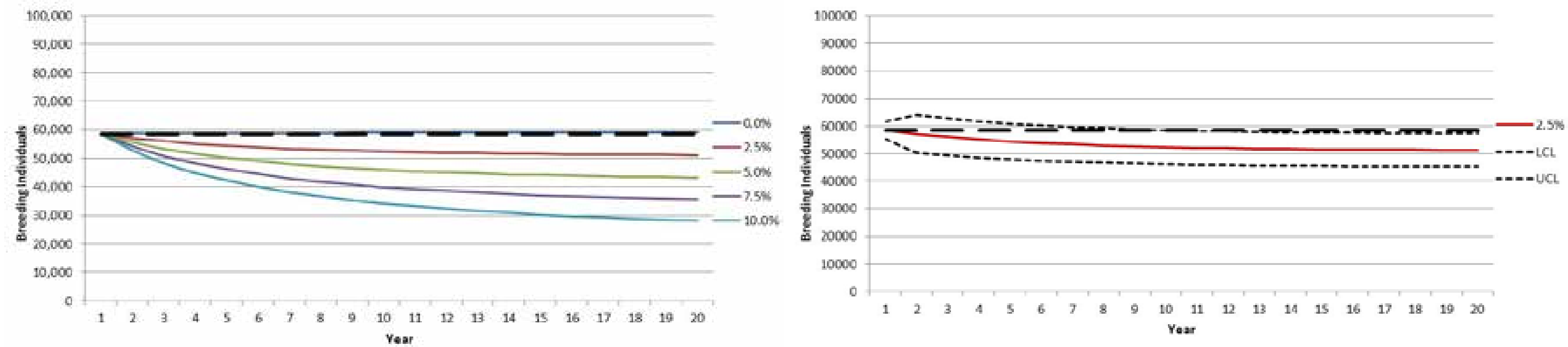
[1] Adkins et al. (in press) abundance estimate was not available when modeling exercise in Appendix E-1 was conducted. It was available for Appendix E-2 modeling exercises.

Table E-1 2. Results from sensitivity analysis showing the percent decrease in lambda (N_{t1}/N_o) and 95 percent LCL and UCL when each input parameter value was independently decreased by 10 percent.

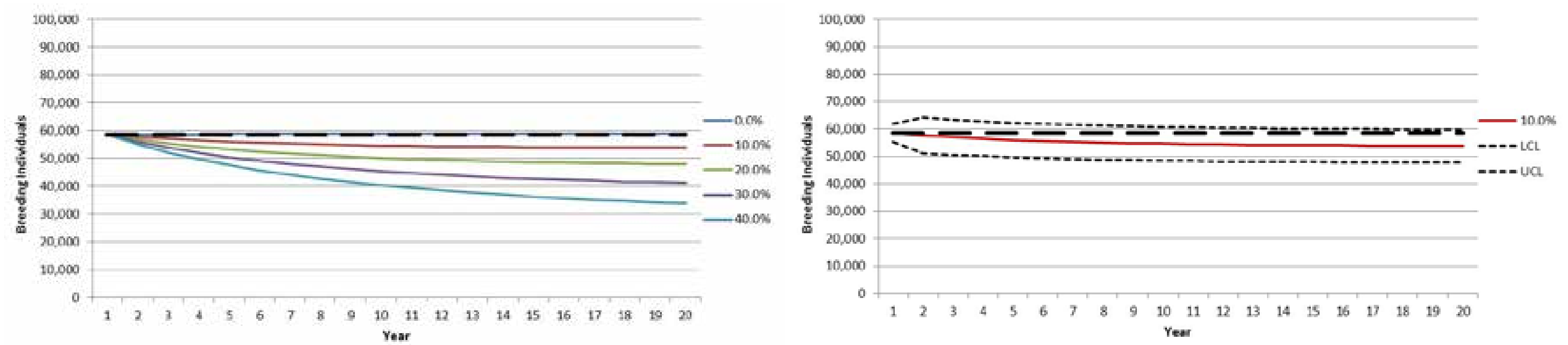
Parameter	Percent Decrease in Lambda (95%LCL-UCL)
S_{ASY}	19 (26-13)
S_{SY}	6 (15-0)
S_{HY}	6 (15-0)
$ASY_{>3y\%b}$	5 (15-0)
E	3 (13-0)
S_{chick}	3 (13-0)
H	3 (13-0)
$ASY_{3y\%b}$	1 (12-0)
$SY_{\%b}$	0 (11-0)

Figure E-1 1. Population trajectories for the western population of double-crested cormorants under different annual take scenarios: I) Percent of breeding individuals culled every year, II) Percent of nests oiled every year. The initial abundance and carrying capacity value used in simulations was the Adkins and Roby (2010) estimate 58,480 breeding individuals. The horizontal dashed black line shows initial population size (i.e., static population). The left panel shows population trajectories for a range of take values. The right panel shows the lowest take values with 95 percent Lower and Upper Confidence Limits (LCL and UCL).

I) Percent of breeding individuals culled every year



II) Percent of nests oiled every year



Literature Cited

Adkins, J. Y. and D. D. Roby, et al. 2010. A status assessment of the double-crested cormorant (*Phalacrocorax auritus*) in western North America: 1998-2009. Final Report to U.S. Army Corps of Engineers.

Blackwell, F. B., M. A. Stapanian, and D.V.C. Weseloh. 2002. Dynamics of the Double-crested Cormorant Population on Lake Ontario. Wildlife Society Bulletin 30: 345–353.

Dooley, J. 2012. Use of the Potential Biological Removal (PBR) Model for Assessing Allowable Take Levels: Applicability for the Issuance of USFWS Permits. Presentation at U.S. Fish and Wildlife Service, Migratory Bird Habitat Programs Coordination Meeting, September 25, 2012.

Hatch, J. J. and D. V. Weseloh. 1999. Double-crested Cormorant (Phalacrocorax auritus), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online.

Ludwig, J.P. and C.L. Summer. 1995. Final report of the SERE Group Ltd. study to: Model the population of Double-crested Cormorants in the Les Cheneaux region of Lake Huron, and to collect data relevant to fish species utilization by cormorants and other waterbirds from the northern Great Lakes. The SERE Group, Ltd., Eureka, MI.

Pacific Flyway Council. 2012. Pacific Flyway Plan: A Framework for the Management of Double-crested Cormorant Depredation on Fish Resources in the Pacific Flyway. Pacific Flyway Council, U.S. Fish and Wildlife Service, Portland, Oregon. 55pg.

R Development Core Team. 2008. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0. Available at: http://www.R-project.org.

Runge, M. C., W. L. Kendall, J. D. Nichols. 2004. Exploitation. Pages 303–328 in Sutherland W. J., I. Newton, and R. E. Green, eds. Bird Ecology and Conservation: A Handbook of Techniques. Oxford University Press, Oxford, UK.

Runge, M. C., J. R. Sauer, M. L. Avery, B. F. Blackwell, and M. D. Koneff. 2009. Assessing allowable take of migratory birds. Journal of Wildlife Management 73(4):556–565.

Slade, N. A., R. Gomulkiewicz, and H. M. Alexander. 1998. Alternatives to Robinson and Redford's Method of assessing overharvest from incomplete demographic data. Conservation Biology 12:148–155.

U.S. Fish and Wildlife Service (USFWS). 2009. Final Environmental Assessment: Extended Management of Double-crested Cormorants under 50 CFR 21.47 and 21.48. U.S. Dept. of the Interior, USFWS, Div. of Migratory Bird Management, 4401 N. Fairfax Drive MBSP-4017, Arlington, VA 22203.

U.S. Fish and Wildlife Service (USFWS). 2014. Draft Environmental Assessment: Management of Double-crested Cormorants under 50 CFR 21.47 and 21.48. U.S. Dept. of the Interior, USFWS, Div. of Migratory Bird Management, 4401 N. Fairfax Drive MBSP-4017, Arlington, VA 22203; in cooperation with U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services.

Van Der Veen, H. E. 1973. Some aspects of the breeding biology and demography of the Double-crested Cormorants (Phalacrocorax auritus) of Mandarte Island. Ph.D. thesis. Zoologisch Laboratorium der Rijksuniversiteit te Groningen, Groningen.

Williams, B.K., J.D. Nichols, and M.J. Conroy. 2001. Analysis and management of animal populations. Academic Press, San Diego, CA.

Appendix E-2: Population Model Analyses to Assess Proposed Take Levels on East Sand Island and the Western Population of Double-crested Cormorants

Background and Methods

The model described in Appendix E-1 was used to develop take levels described in Phase I of Alternatives C and D, which have objectives to reduce the East Sand Island double-crested cormorant (DCCO) colony to the target size of 5,380 to 5,939 breeding pairs by the end of the 2018 timeline of the 2014 FCRPS Biological Opinion (NOAA 2014, see Section 1.1.5). The model was then used to assess the potential effects of the take levels and management strategies proposed in Alternatives C and D on the DCCO colony on East Sand Island and how those take levels would affect, consequently, the western population of DCCOs.

The model was fit to observed DCCO abundance on East Sand Island and Rice Island from 1989–2013; observed abundance data came from NOAA (2014) (see Appendix D) and Roby et al. (2014). DCCOs nested on both East Sand Island and Rice Island before 1999, and then exclusively on East Sand Island thereafter. For modeled abundance estimates, 3,694 breeding individuals was used as the initial abundance in 1989, and 25,834 breeding individuals, the 10-year average during 2004–2013, was used as the final abundance in 2013 (see Table E-2 1 for model input parameters). To assess model fit, an R-squared value was calculated using the equation:

$$R^2 = 1 - \frac{\sum_i^N (y_i - \hat{y}_i)^2}{\sum_i^N (y_i - \bar{y})^2}$$

where,

y_i	= observed abundance in year i,
$\hat{y}_i$	= model predicted abundance in year i, and
$\bar{y}_i$	= average observed abundance from year i to N

For future growth trajectories, annual take percentages (i.e., percentage of the colony taken) were identified for Phase I of Alternatives C and D to reduce the DCCO colony on East Sand Island from 25,834 breeding individuals to the population target of 11,319 breeding individuals, as required under reasonable and prudent alternative 46 of the 2014 FCRPS Biological Opinion (stated as 5,380 to 5,939 nesting pairs; NOAA 2014). If lethal take is initiated in 2015 and management actions are implemented for four years, the target colony size on East Sand Island would be reached by the end of 2018 (lethal control taking place in 2015, 2016, 2017, and 2018). The Corps would initially undertake a 4-year lethal strategy to achieve the target colony size. Based on the first year's results, and in coordination with the Adaptive Management Team, the lethal strategy could be adjusted to a 3- or 2-year strategy by increasing take levels after the first year (see Discussion). The lethal strategies presented are a 4-year lethal strategy, with equal take percentages of the colony in years 1 to 4, an adjusted 3-year lethal strategy with increased and equal take percentage in years 2 and 3, and an adjusted 2-year lethal strategy with increased take percentage in year 2.

The lethal take scenario modeled used equal individual take and associated active nest loss percentages per year (i.e., a one to one individual take to associated active nest loss ratio). This is the greatest possible amount of associated active nest loss that could occur when taking individuals during the breeding season (i.e., each adult taken is assumed to have an associated active nest that would subsequently fail). Lower associated active nest loss is expected since a proportion of the proposed take would occur prior to the initiation of nesting, and some pairs, associated with the same nest, would be taken. Future population trajectories were modeled under two carrying capacity scenarios: 1) a constant carrying capacity and 2) a carrying capacity decreased by 20 percent each year for 4 years, then remaining static at that level. The constant carrying capacity scenario (scenario 1) incorporates the growth potential of the colony without a reduction in carrying capacity. The 20 percent reduction in carrying capacity each year for four years scenario (scenario 2) is the percent reduction that would result in the carrying capacity approaching but not dropping below the target colony size upper range (11,878 breeding individuals), as could potentially be achieved by implementing lethal and non-lethal measures that could reduce carrying capacity during Phase I and II of Alternatives C and D. An abundance of 25,834 breeding individuals, the 10-year average during 2004–2013, was used as the initial abundance. Carrying capacity for the first scenario and carrying capacity for year one for the second scenario was 29,832 breeding individuals, the peak colony size observed during 2013 (i.e., the greatest DCCO abundance ever recorded on East Sand Island). Take percentages were evaluated at 0.5 percent intervals. Take percentage 95 percent Lower and Upper Confidence Limits (LCL and UCL) were estimated as the values that resulted in the 95 percent LCL and UCL point estimates of a given population size as central values from simulations. We estimated the number of individuals taken and associated active nests lost each year as the individual take percentage for that year multiplied by the initial number of breeding individuals for that year.

Estimated annual individual and associated loss levels on East Sand Island were then added to potential take levels that could occur elsewhere in the western population of DCCOs to estimate annual take percentages of the western population of DCCOs. This potential total annual take for the entire western population includes the proposed annual take levels on East Sand Island identified in Phase I of Alternatives C and D and an additional 936 individuals. This is the estimated potential annual take that could occur in the states that fall within the western population of DCCO boundary (Arizona, California, Idaho, Oregon, Nevada, Utah, Washington and portions of Colorado, Montana, New Mexico and Wyoming west of the Continental Divide) upon implementation of Alternative C or D. The 936 individual additional take estimate was derived by projecting the current (2009-2013) authorized take for other migratory bird DCCO take permits within the western population boundary minus the average reported take for 1998-2008 (USFWS, unpubl. data). The average reported take of DCCO within the western population from 1998-2008 is accounted for within the western population abundance estimates from Adkins et al. (in press) and thus are incorporated into the model. Simulations using the western population of DCCO take percentages were conducted using the model described in Appendix E-1 to determine the population trajectory and annual abundance of the western population of DCCOs.

Take of DCCOs as a percentage of the western population was calculated by dividing total annual take (annual take on East Sand Island plus 936 DCCOs) by annual abundance of the western population. The DCCO population model was used deterministically to estimate abundance of the western population in year t+1 in order to calculate the year t+1 take percentage. Estimated annual take percentages were then used in simulations using the DCCO population model to assess annual abundance of the western population. Once the targeted colony size of East Sand Island was reached, take levels were changed to reflect the end of lethal removal of individuals and the loss of associated active nests on East Sand Island. Annual take of 936 DCCOs was still included every year, as this take throughout the western population of DCCOs would most likely continue in the future. Density dependence was estimated using an initial abundance of 41,660 breeding individuals in 1990 (Tyson et al. 1997) and a final abundance of 62,400 breeding individuals in 2009 (20 years; Adkins et al. in press). For future 20-year population trajectories, an estimate of 62,400 breeding individuals was used for the initial abundance and carrying capacity.

Results

For the DCCO colony on East Sand Island, the model fit the observed DCCO abundance data during 1989–2013 well; R-squared value was 85 percent when projecting abundance to 25,834 breeding, the 2004–2013 average (Figure E-2 1), and 90 percent when projecting abundance to 29,832 breeding individuals, the peak colony size observed during 2013 (not shown).

Model results for Phase I of Alternatives C and D, showing the 4-year lethal strategy, and the adjusted 3-year and 2-year lethal strategies (under carrying capacity scenarios 1 and 2), are provided in Table E-2 2. Annual take is a percentage of the colony; thus, as a percentage of a population is removed, the next year's starting population would be smaller, resulting in a smaller number of individuals removed under the same take percentage.

Under the 4-year lethal strategy under scenario 1 (constant carrying capacity), annual individual and associated active nest loss rates of 22.5 percent (20–24.5 percent) projected a DCCO abundance on East Sand Island approaching the population target after year 4 (Figure E-2 1). This corresponded to 17,392 total individuals taken during all 4 years (i.e., 5,811, 4,625, 3,799, and 3,157 individuals taken in years 1-4, respectively; Table E-2 2). Under the adjusted 3-year strategy, annual individual and associated active nest loss rates increased to 30.5 percent (26.5–34.5 percent) during years 2 and 3, resulting in 16,707 total individuals taken during all 3 years (i.e., 5,811, 6,274, and 4,622 individuals taken in years 1-3, respectively; Table E-2 2). Under the adjusted 2-year strategy, annual individual and associated active nest loss rates increased to 47.5 percent (41.5–53 percent) during year 2, resulting in 15,576 total individuals taken both years (i.e., 5,811 and 9,765 individuals taken in years 1 and 2, respectively; Table E-2 2).

Under the 4-year lethal strategy under scenario 2 (reduced carrying capacity), annual individual and associated active nest loss rates of 18 percent (14.5–21.5 percent) projected a DCCO abundance on East Sand Island approaching the population target after year 4 (Figure E-2 1). This corresponded to 14,519 total individuals taken during all 4 years (i.e., 4,650, 3,914, 3,266, and 2,688 individuals taken in years 1-4, respectively; Table E-2 2). Under the adjusted 3-year strategy, annual individual and associated active nest loss rates increased to 27 percent (21.5–32.5 percent) during years 2 and 3, resulting in 14,874 total individuals taken during all 3 years (i.e., 4,650, 5,868, and 4,356 individuals taken in years 1-3, respectively; Table E-2 2). Under the adjusted 2-year strategy, annual individual and associated active nest loss rates increased to 48.5 percent (42.5–54.5 percent) during year 2, resulting in 15,198 total individuals taken both years (i.e., 4,650 and 10,548 individuals taken in years 1 and 2, respectively; Table E-2 2).

Annual individual and associated active nest loss levels on East Sand Island plus the additional estimated 936 individuals that are expected to be taken per year (see above) within the western population were converted into western population take percentages (see Table E-2 3). Under the 4-year lethal strategy under scenario 1 (constant carrying capacity), annual take percentages of the western population of DCCOS ranged from 8–11 percent for individuals and 7–9 percent for associated active nests. These take percentages projected a reduction in abundance from 62,400 breeding individuals to 45,225 (40,214–50,236) breeding individuals after year 4, or a 28 percent reduction (Figure E-2 2). Under the adjusted 3-year lethal strategy, annual take percentages increased to 11–13 percent for individuals and 9–11 percent for associated active nests during years 2 and 3 (Table E-2 3). The adjusted 3-year strategy projected an estimated 45,924 (40,677–51,171) breeding individuals in the western population of DCCOs after year 3, or a 26 percent reduction (Figure E-2 2). Under the adjusted 2-year lethal strategy, annual take percentage increased to 19 percent for individuals and 17 percent for associated active nests during year 2 (Table E-2 3). The 2-year strategy projected an estimated 46,314 (40,842–51,787) breeding individuals in the western population after year 2, or a 26 percent reduction (Figure E-2 2).

Under the 4-year lethal strategy under scenario 2 (reduced carrying capacity), annual take percentages of the western population of DCCOS ranged from 7–9 percent for individuals and 5–7 percent for associated active nests. These take percentages projected a reduction in abundance from 62,400 breeding individuals to 48,303 (42,866–53,740) breeding individuals after year 4, or a 23 percent reduction (Figure E-2 2). Under the adjusted 3-year lethal strategy, annual take percentages increased to 10–12 percent for individuals and 8–10 percent for associated active nests during years 2 and 3 (Table E-2 3). The adjusted 3-year strategy projected an estimated 47,712 (42,159–53,264) breeding individuals in the western population of DCCOs after year 3, or a 24 percent reduction (Figure E-2 2). Under the adjusted 2-year lethal strategy, annual take percentage increased to 20 percent for individuals and 18 percent for associated active nests during year 2 (Table E-2 3). The 2-year strategy projected an estimated 46,613 (41,098–52,127) breeding individuals in the western population after year 2, or a 25 percent reduction (Figure E-2 2).

Using mid-point values of the two carrying capacity scenarios, the 4-year lethal strategy projected an abundance of 46,764 (41,540–51,988) breeding individuals in the western population of DCCOs after year 4, or a 25 percent reduction. The adjusted 3-year lethal strategy projected an abundance of 46,818 (41,418–52,218) breeding individuals in the western population after year 3, or a 25 percent reduction. The adjusted 2-year lethal strategy projected an abundance of 46,464 (40,970–51,957) breeding individuals after year 2, or a 26 percent reduction.

Discussion
A depredation permit application would be submitted annually by the Corps for approval by the USFWS prior to any lethal take. The 4-year lethal strategy, and take levels of the mid-point between the two carrying capacity scenarios (Table E-2 4), would be the initial strategy the Corps would use to achieve the target colony size under Phase I of Alternatives C and D. The 4-year lethal strategy includes annual take of 20.3 percent of the breeding individuals per year, or approximately 5,230, 4,270, 3,533, and 2,923 DCCOs in years 1 to 4, respectively. Proposed individual take levels would include and account for the associated amount of indirect nest loss that could occur from taking the proposed number of individuals. The two carrying capacity scenarios modeled for East Sand Island likely represent the extremes that could occur: no reduction in carrying capacity (scenario 1) and carrying capacity reduced to and maintained at the target size (scenario 2). Mid-point values were chosen to represent an intermediate value between these two extremes. Non-lethal techniques will be implemented concurrently with lethal techniques, and the reduced carrying capacity scenario modeled to some degree the potential effect of concurrent non-lethal management on take levels. However, the actual extent that non-lethal management can reduce carrying capacity is unknown.

Take of individuals is the primary lethal method proposed. Aside from limited egg take to support implementation of non-lethal methods (i.e., up to 500 eggs on East Sand Island), egg take is not proposed as a primary lethal method. However, loss of active nests could occur indirectly from take of breeding adults that are actively nesting when culled, if culling sessions are not completed prior to the onset of nesting. Based on prior nest chronology dates (see Table 4-1), active nests (i.e., time period from egg laying to presence of fledglings) typically are present on East Sand Island from March 27 to July 5. A conservative approach was used for modeling associated active nest loss by depicting the most extreme associated active nest loss scenario within the proposed take percentages (1 active nest per 1 individual, which represents each individual having separate active nests).

The 4-year lethal strategy could be adjusted to a 3- or 2-year strategy by increasing take levels after the first year of lethal management. Take percentage in year 2 and 3 could be increased to 28.8 percent for the adjusted 3-year strategy (6,071 and 4,489 DCCOs taken in year 2 and 3) or 48.0 percent for the adjusted 2-year strategy (10,156 DCCOs taken in year 2; Table 2-5). The benefits of a shorter lethal take strategy would be less overall adverse effects from management activities to the DCCO colony and other species on East Sand Island and reduced implementation costs. The thresholds for adjusting year strategies would be based upon the first year's culling efficiency (i.e., the number of DCCOs lethally taken per day of culling and the total number of days from the first to last culling session) and if the frequency that culling took place did not exceed the lower dispersal threshold (i.e., observed abundance is 70 percent or less than the expected abundance one week after a culling event). The adjusted 3-year or 2-year could be selected if the proposed take levels for the respective strategy are expected to be achieved by June 26 (i.e., approximate mid-point of when active nests are typically present on East Sand Island [March 27–July 25]) and the frequency of culling to achieve the proposed take levels would not exceed the lower dispersal threshold. For example, if 5,230 DCCOs were lethally taken in year 1 in 10 days of culling within a 30 day date range from April 1 to 30, 523 DCCOs (5,230/10) would have been taken per day of culling, or approximately 174 (5,230/30) DCCOs per day during the date range culling took place. With this culling efficiency, the proposed take levels under the adjusted 3-year and 2-year strategy would likely require a culling date range of 35 (6,067/174) and 58 (10,156/174) days, respectively, assuming the same culling frequency would occur (culling 33 percent of the days during the date range culling took place) and this culling frequency would not exceed the lower dispersal threshold. If this level of take could likely occur by June 26, the Corps, in consultation with the Adaptive Management Team, would then consider adjusting year strategies. Selecting this date (June 26) as a measure for adjusting future year's proposed take levels would be contingent upon implementation occurring as planned.

The proposed take levels would be followed by the Corps for requesting take levels in an annual depredation permit application. Lethal take within a given year would cease once annual take levels, authorized in an annual depredation permit, are achieved, or the target colony size, based on peak annual abundance, is achieved. The proposed take levels could be adjusted if the peak observed annual colony size during late incubation deviates from predicted annual colony size greater than what is expected due to natural annual variation in colony size. Annual variation in colony size is expected. During 2004 to 2013, the average percentage change in colony size between consecutive years was 11 percent; the greatest percent change was 21 percent between 2012 and 2013 (see Figure 1-2). The take levels proposed under all year strategies could decrease if peak observed annual colony size during late incubation, accounting for expected annual variation, becomes lower than model predicted colony size. If peak observed colony size becomes greater than model predicted colony size, additional NEPA review and supporting analyses would be required for increased take levels greater than those proposed and analyzed in the EIS. Any adjustment to year strategies or take levels would be coordinated with the Adaptive Management Team (see Chapter 2.2.3 for more complete description of field methods and adaptive management thresholds).

For the western population of DCCOs analysis, carrying capacity was modeled as the initial abundance of the western population (62,400 breeding individuals; Adkins et al. in press), as this was determined to be the most objective value. There is uncertainty when choosing a carrying capacity value. Carrying capacity cannot be empirically known, and carrying capacity in the future could be similar, lower, or higher compared to present conditions. Modeling carrying capacity as the initial abundance suggests a rebound in the western population of DCCOs after a decline as a result of implementation of Phase I of Alternatives C or D, as shown in Figure E-2 2. It is unknown whether or not the western population would be capable of that increase if the East Sand Island colony would be maintained at the target size. Within the coastal states and provinces, which account for approximately 90 percent of the western population of DCCOs, DCCO abundance increased 71 percent during the last two decades, but nearly all of the growth of the western population of DCCOs was attributed to abundance increase at the East Sand Island colony (Adkins et. al in press, see Figure 4-2). With nesting habitat reduced and growth on East Sand Island limited, it is possible that carrying capacity of the western population of DCCOs could be reduced; thus, the abundance of the western population in the future would not increase after the abundance reduction on East Sand Island under Phase I of Alternative C or D. Conversely, mortality factors known to limit DCCO populations prior to the 1970s (i.e., environmental contaminants [DDT was banned in 1972] and hunting [DCCOs were protected under the MBTA in 1972]) have been reduced or eliminated, along with improved waterbird conservation, management, and habitats throughout the United States. Although the particular colony where most of the observed growth of the western population of DCCOs would be limited, large-scale environmental, regulatory, and management changes that have occurred over the past decades could allow for carrying capacity of the western population of DCCOs in the future to be similar to or greater than current levels. DCCOs that nest on East Sand Island typically spend half of the year away from East Sand Island and, during non-breeding years, they could be associated with other areas; thus, the increase in abundance at the East Sand Island colony most likely cannot be solely sourced to the location alone and likely reflects beneficial environmental changes that have occurred throughout the geographic area occupied by DCCOs that nest on East Sand Island.

Take levels from the modeling approach account for expected density-dependent abundance increases based upon prior observed growth rates of both the western population of DCCOs and the DCCO colony on East Sand Island. Growth rate data and input parameter values used in the model were specific to the western population and

East Sand Island or are demographic parameters intrinsic to the species (e.g., lifespan). The difference between the 10-year average colony size on East Sand Island (25,834 breeding individuals) and the value of the target population size (11,319 breeding individuals) is 14,515 breeding individuals. Total proposed take levels on East Sand Island, as mid-point values from all year strategies, ranged from 15,386 to 15,956 breeding individuals (Table E-2 4). The difference in abundance between the ca. 2009 estimated size of the western population of DCCOs (62,400 breeding individuals) from Adkins et al. (in press) and the projected population abundance (46,464 to 46,818 breeding individuals) after implementation of Phase I of Alternatives C or D is 15,582 to 15,936 breeding individuals. A western population of DCCO abundance between 46,464 and 46,818 breeding individuals after implementation of Phase I of Alternatives C and D is approximately 5,000 breeding individuals greater than abundance observed around 1990 (41,660 breeding individuals; Tyson et al. 1997). Since 1990, the growth of the western population of DCCOs has been primarily associated with the growth of the East Sand Island colony. Thus, it appears that the western population of DCCOs is sustainable at approximately ca. 1990 numbers. A sustainable population is defined for this analysis as a population that is able to maintain numbers above a level that would not result in a major decline or cause a species to be threatened or endangered. (see Section 4.2.2 for a more complete discussion).

Conservative modeling approaches were used with regard to the initial East Sand Island colony size, associated active nest loss, and incorporation of additional take (936 individuals per year) within the western population of DCCOs. This could result in proposed take levels that underestimate the level of take needed to achieve the target colony size on East Sand Island. Similarly, observed abundance for the western population of DCCOs and the East Sand Island colony could be higher than predicted. The 10-year average abundance was used as the initial East Sand Island colony size, and proposed take levels are derived from this initial colony size. However, the 2013 abundance estimate (largest recorded) was approximately 4,000 breeding individuals greater than the 10-year average; thus, the actual East Sand Island colony size at the time of implementation of Phase I of Alternative C and D may be higher than the abundance used in the model. The amount of associated active nest loss modeled (i.e., 1 nest per 1 individual taken ratio), represents the most extreme associated active nest loss scenario possible. Thus, future trajectories include more active nest loss than will most likely actually occur since it is likely that some culling will occur prior to nest initiation (i.e., no nest per individual) and some nesting pairs will be culled together (i.e., one active nest lost per two individuals). Lastly, the 936 DCCOs each year included in addition to the annual take levels on East Sand Island represent potential, authorized take that could occur in the future. Actual take levels from this potentially authorized amount could be lower. Because of these modeling approaches, trajectories for the East Sand Island DCCO colony and the western population of DCCOs may be potentially conservative compared to actualized conditions that may occur.

Table E-2 1. Description, mean value, coefficient of variation (CV), and lower and upper truncation points (LTrunc/UTrunc) of parameters used in the DCCO population model simulations.

Parameter	Description	Mean Value; CV; LTrunc/UTrunc	Reference
$N_{WP\_int\_future}$	Initial number of breeding individuals in the western population (ca. 2009) for modeling future abundance	62,400; 0.10; 59,660/65,940	Adkins et al. in press
$N_{ESI\_int\_model\ fit}$	Initial number of breeding individuals on East Sand Island in 1989 for assessing model fit to observed data	3,694; 0.10; 3,194/4,194	NOAA 2014
N_{ESI_future}	Initial number of breeding individuals on East Sand Island (2004–2013 average) for modeling future abundance	25,834; 0.08; 21,648/30,020	Roby et al. 2014
*a	recruitment parameter	0.396; 0.15; 0.25/0.55	USFWS 2014, ancillary data = 0.471 (0.384-0.553) Slade method = 0.412
b_{WP}	density dependence parameter to project western population from 41,660 breeding individuals in 1990 to final population size (carrying capacity) of 62,400 breeding individuals in ca. 2009	-0.0000034936; 0.10; mean±0.50*mean	
$b_{ESI\_model\ fit}$	density dependence parameter to project the DCCO colony on East Sand Island from 3,694 breeding individuals in 1989 to final population size of 25,834 breeding individuals (2004–2013 average) in 2013	-0.000007957; 0.10; mean±0.50*mean	
b_{ESI_future}	density dependence parameter to project the DCCO colony on East Sand Island from 25,834 breeding individuals (2004–2013 average) to final population size (carrying capacity) of 29,832 breeding individuals (peak colony size in 2013) in 20 years	-0.000007342; 0.10; mean±0.50*mean	
S_{HY}	hatch year survival	0.4; 0.10; 0.25/0.55	Hatch and Wesoloh 1999 = 0.5 USFWS 2009 = 0.297 USFWS 2014, ancillary data = 0.446 Blackwell et al. 2002 = 0.30-0.35
S_{SY}	second year survival	0.75; 0.10; 0.65/0.85	Hatch and Wesoloh 1999 = 0.75 USFWS 2009 = 0.778 USFWS 2014, ancillary data = 0.835

Parameter	Description	Mean Value; CV; LTrunc/UTrunc	Reference
S_{ASY}	after second year survival	0.85; 0.10; 0.80/0.90	Hatch and Wesoloh 1999 = 0.85 USFWS 2009 = 0.841 USFWS 2014, ancillary data = 0.884
$SY_{\%b}$	proportion of second year individuals that return to breed	0.17; 0.10; 0.02/0.32	Hatch and Wesoloh 1999; Van Der Veen 1973 = 0.17
$ASY_{3y\%b}$	proportion of after second years that return to breed in year 3	0.79; 0.10; 0.64/0.94	Hatch and Wesoloh 1999; Van Der Veen 1973 = 0.79
$ASY_{>3y\%b}$	proportion of after second years that return to breed in year >3	0.98; 0.10; 0.94/1.0	Hatch and Wesoloh 1999; Van Der Veen 1973 = 0.98
*F	number of year-end fledglings produced per breeding pair	2.08; 0.16; 1.5/2.5	Hatch and Weseloh 1999 = 1.2 to 2.4 (mean = 1.8) Blackwell et al. 2002 = 1.7-2.5 BRNW data = 2.08
n	number of years after second years remain in population	15	Hatch and Weseloh 1999 = 6.1 mean life expectancy; oldest bird 17 yr)
E	number of eggs per breeding pair	3.85; 0.10; 3.25/4.45	Hatch and Weseloh (1999) = 2.7 to 4.1 (mean = 3.4; mode = 4) BRNW data = 3.85
H	hatch rate of eggs	0.8; 0.10; 0.60/1.0	Hatch and Weseloh (1999) = 0.5 to 0.7 (mean = 0.6) BRNW data = 0.8
S_c	survival rate of chick to fledgling	0.675; 0.10; 0.5/0.85	BRNW data = 0.675 (28day post-hatch survival = 0.75; 28day to fledgling survival = 0.90).

*Parameters were calculated using equations 3 and 4 in Appendix E-1, respectively.

Table E-2 2. Modeled estimated take of individuals and associated active nests that resulted in the DCCO colony on East Sand Island approaching, but not dropping below, the 2014 FCRPS Biological Opinion population target of 11,319 breeding individuals under the 4-year lethal strategy and the adjusted 3-, and 2-year lethal strategies proposed in Phase I of Alternatives C and D. Shown are estimated annual colony abundance (N), number of individuals taken and associated active nests lost, and 95 percent Lower and Upper Confidence Limits (LCL and UCL). Individual and associated active nest loss percentages are equal, as 1 nest per individual taken was modeled. (A) shows estimates when carrying capacity was modeled constant at 29,832 breeding individuals. (B) shows estimates when carrying capacity was modeled as decreasing 20 percent each year for 4 years when starting at 29,832 breeding individuals, then remaining static (See Figure E-2 1).

A) CONSTANT CARRYING CAPACITY

	4 yr: Ind (22.5%) + nest (22.5%)					3 yr adjusted: yr 1 (22.5%); yr 2-3 (30.5%)					2 yr adjusted: yr 1 (22.5%); yr 2 (47.5%)				
Year	N	# Ind Taken	# Associated Active Nests Lost	LCL	UCL	N	# Ind Taken	# Associated Active Nests Lost	LCL	UCL	N	# Ind Taken	# Associated Active Nests Lost	LCL	UCL
1	25,826	5,811	5,811	5,008	6,614	25,826	5,811	5,811	5,008	6,614	25,826	5,811	5,811	5,008	6,614
2	20,556	4,625	4,625	4,081	5,170	20,556	6,274	6,274	5,536	7,011	20,556	9,765	9,765	8,617	10,913
3	16,885	3,799	3,799	3,367	4,232	15,155	4,622	4,622	4,097	5,148	11,436				
4	14,033	3,157	3,157	2,814	3,501	11,406					12,632				
5	11,479					12,146					13,258				
6	12,128					12,593					13,537				
7	12,776					13,178					14,612				
8	13,568					14,372					16,026				
9	14,817					15,791					17,435				
10	16,236					17,211					18,815				
11	17,646					18,606					20,142				
12	19,023					19,952					21,396				
13	20,345					21,228					22,560				
14	21,590					22,416					23,624				
15	22,744					23,504					24,581				
16	23,796					24,485					25,430				
17	24,741					25,358					26,174				
18	25,577					26,123					26,818				
19	26,307					26,786					27,370				
20	26,939					27,356					27,839				
Total		17,392	17,392	15,269	19,516		16,707	16,707	14,641	18,772		15,576	15,576	13,625	17,526

B) CARRYING CAPACITY DECREASED 20% PER YEAR

	4 yr: Ind (18%) + nest (18%)					3 yr adjusted: yr 1 (18%); yr 2-3 (27%)					2 yr adjusted: yr 1 (18%); yr 2 (48.5%)				
Year	N	# Ind Taken	# Associated Active Nests Lost	LCL	UCL	N	# Ind Taken	# Associated Active Nests Lost	LCL	UCL	N	# Ind Taken	# Associated Active Nests Lost	LCL	UCL
1	25,833	4,650	4,650	4,006	5,294	25,833	4,650	4,650	4,006	5,294	25,833	4,650	4,650	4,006	5,294
2	21,747	3,914	3,914	3,454	4,375	21,747	5,868	5,868	5,178	6,558	21,747	10,548	10,548	9,304	11,792
3	18,144	3,266	3,266	2,877	3,654	16,134	4,356	4,356	3,839	4,873	11,394				
4	14,935	2,688	2,688	2,373	3,004	12,039					12,163				
5	12,023					12,139					12,155				
6	11,723					11,680					11,561				
7	11,475					11,366					11,491				
8	11,334					11,402					11,611				
9	11,416					11,531					11,711				
10	11,552					11,639					11,794				
11	11,665					11,729					11,862				
12	11,758					11,803					11,919				
13	11,836					11,864					11,965				
14	11,899					11,914					12,003				
15	11,952					11,955					12,034				
16	11,995					11,989					12,059				
17	12,030					12,016					12,080				
18	12,059					12,039					12,096				
19	12,082					12,057					12,110				
20	12,102					12,072					12,121				
Total		14,519	14,519	12,710	16,327		14,874	14,874	13,023	16,725		15,198	15,198	13,310	17,086

Table E-2 3. Modeled estimated take of individuals (ind) and associated active nest loss as a percentage of the western population (WP) of DCCOs under the 4-year lethal management strategy and the adjusted 3-, and 2-year lethal management strategies proposed in Phase I of Alternatives C and D. Take levels include 936 additional individuals taken per year in other areas of the western population, not included in modeled parameters. See Methods for description of how percentages were derived. (A) shows estimated take levels from East Sand Island when carrying capacity was modeled constant at 29,832 breeding individuals. (B) shows estimated take levels from East Sand Island when carrying capacity was modeled as decreasing 20 percent each year for 4 years when starting at 29,832 breeding individuals, then remaining static (See Figure E-2 1).

A) CONSTANT CARRYING CAPACITY

Year	WP N	WP N LCL	WP N UCL	ESI Ind Take	Additional Ind Take in WP	Total Ind Take	% Ind Take of WP	ESI Associated Active Nests Lost	% Associated Active Nest Loss of WP
4 yr: Ind (22.5%) + nest (22.5%)									
1	62400	59311	66294	5811	936	6747	11%	5811	9%
2	55966	49154	62777	4625	936	5561	10%	4625	8%
3	51456	45340	57572	3799	936	4735	9%	3799	7%
4	48307	42707	53907	3157	936	4093	8%	3157	7%
5	45225	40214	50236						
3 yr adjusted: yr 1 (22.5%); yr 2-3 (30.5%)									
1	62400	59311	66294	5811	936	6747	11%	5811	9%
2	55966	49154	62777	6274	936	7210	13%	6274	11%
3	49766	43906	55626	4622	936	5558	11%	4622	9%
4	45924	40677	51171						
2 yr adjusted: yr 1 (22.5%); yr 2 (47.5%)									
1	62400	59311	66294	5811	936	6747	11%	5811	9%
2	55966	49154	62777	9765	936	10701	19%	9765	17%
3	46314	40842	51787						

B) CARRYING CAPACITY DECREASED 20% PER YEAR

Year	WP N	WP N LCL	WP N UCL	ESI Ind Take	Additional Ind Take in WP	Total Ind Take	% Ind Take for WP	ESI Associated Active Nests Lost	% Associated Active Nest Loss of WP
4 yr: Ind (18%) + nest (18%)									
1	62400	59318	66276	4650	936	5586	9%	4650	7%
2	57214	50284	64143	3914	936	4850	8%	3914	7%
3	53573	47209	59936	3266	936	4202	8%	3266	6%
4	50573	44686	56460	2688	936	3624	7%	2688	5%
5	48303	42866	53740						
3 yr adjusted: yr 1 (18%); yr 2-3 (27%)									
1	62400	59318	66276	4650	936	5586	9%	4650	7%
2	57214	50284	64143	5868	936	6804	12%	5868	10%
3	51301	45165	57436	4356	936	5292	10%	4356	8%
4	47712	42159	53264						
2 yr adjusted: yr 1 (18%); yr 2 (48.5%)									
1	62400	59318	66276	4650	936	5586	9%	4650	7%
2	57214	50284	64143	10548	936	11484	20%	10548	18%
3	46613	41098	52127						

Table E-2 4. Proposed annual take numbers and percentages (mid-points between the two carrying capacity scenarios) under the 4-year lethal strategy and the adjusted 3- and 2-year lethal strategies.

	4-year strategy			Adjusted 3-year strategy			Adjusted 2-year strategy		
Year	# ind taken	% of colony	associated active nests lost[1]	# ind taken	% of colony	associated active nests lost[1]	# ind taken	% of colony	associated active nests lost[1]
1	5230	20.3%	5230	5230	20.3%	5230	5230	20.3%	5230
2	4270	20.3%	4270	6071	28.8%	6071	10156	48.0%	10156
3	3533	20.3%	3533	4489	28.8%	4489			
4	2923	20.3%	2923						
Total	15956		15956	15790		15790	15386		15386

[1]Lethal take of individuals is the proposed direct lethal action. Nest loss values represent the upper bound of potential egg loss that could occur indirectly from taking individuals. The time period of active nests is from egg laying to presence of fledglings. For associated active nests lost, actual numbers would be recorded and reported when determination in the field can be made. If determination cannot be made in the field, March 27 to July 25 would be date range used to report associated active nests lost.

* Take numbers and percentages are mid-points between the two carrying capacity scenarios modeled. The Corps would initially undertake the 4-year lethal strategy and use the associated take levels when applying for a depredation permit application. The adjusted 3-year or 2-year could be selected if the proposed take levels for the respective strategy are expected to be achieved by June 26 (pending implementation) and the frequency of culling to achieve the proposed take levels would not exceed the lower dispersal threshold (observed abundance 70 percent or less than the expected abundance one week after a culling session).

Figure E-2 1. Observed and predicted DCCO abundance on Rice and East Sand Island during 1989–2013 and 20-year trajectories for the estimated annual individual take rate that resulted in the DCCO colony on East Sand Island approaching, but not dropping below, the 2014 FCRPS Biological Opinion population target of 11,319 breeding individuals under the 4-year lethal management strategy and the adjusted 3-, and 2-year lethal management strategies proposed in Phase I of Alternatives C and D. A one to one individual take to associated active nest loss ratio was modeled and population trajectories include both the annual level of individual take and associated nest loss given in parenthesis. (A) shows trajectories when carrying capacity was modeled constant at 29,832 breeding individuals. (B) shows trajectories when carrying capacity was modeled as decreasing 20 percent each year for 4 years when starting at 29,832 breeding individuals, then remaining static. Error bars are 95 percent LCL and UCL.

A)

B)

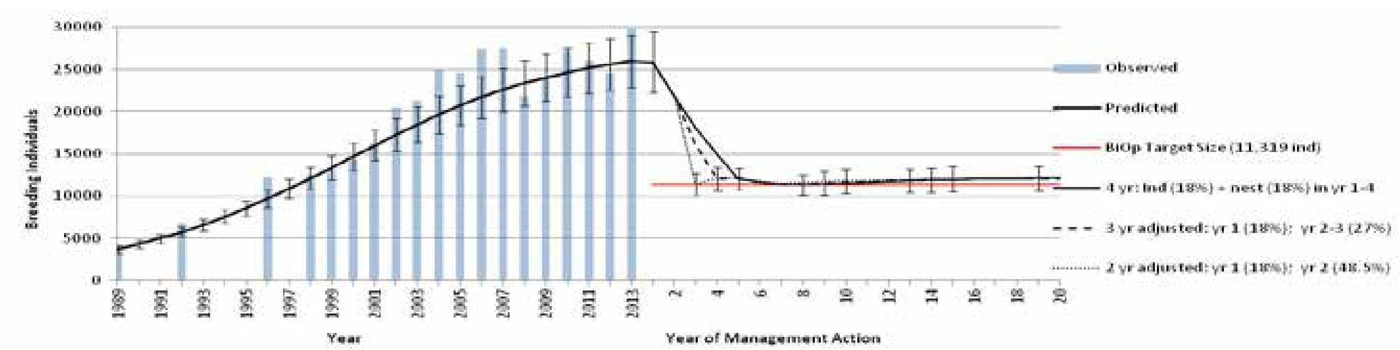
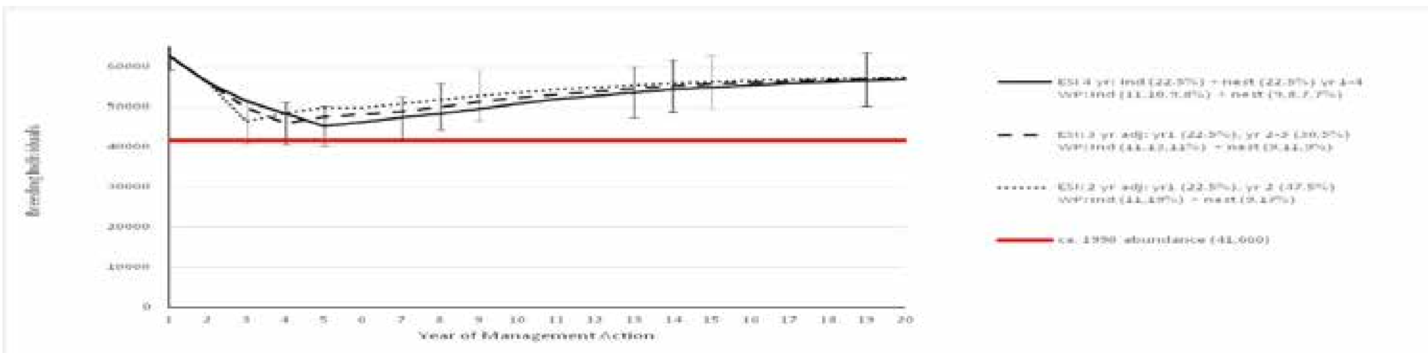
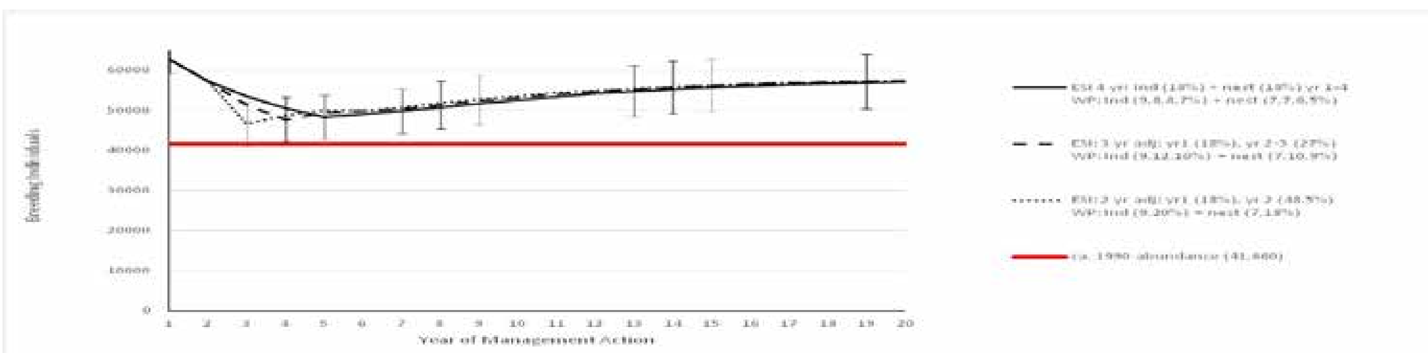


Figure E-2 2. Trajectories of the western population (WP) of DCCOs under the 4-year lethal management strategy and the adjusted 3-, and 2-year lethal management strategies on East Sand Island (ESI) proposed in Phase I of Alternatives C and D. Numbers in parenthesis show the estimated annual individual take and associated active nest loss rate on East Sand Island and the converted annual take rate for the western population used in simulations. Annual western population take rates include annual individual take and associated active nest loss levels on East Sand Island (i.e., a one to one individual take to associated active nest loss ratio was modeled) plus an additional 936 individuals per year (i.e., anticipated take authorization amount not included in modeled parameters). The horizontal line is the ca. 1990 abundance of the western population (41,660 breeding individuals). (A) shows estimated take levels from East Sand Island when carrying capacity was modeled constant at 29,832 breeding individuals. (B) shows estimated take levels from East Sand Island when carrying capacity was modeled as decreasing 20 percent each year for 4 years when starting at 29,832 breeding individuals, then remaining static. Error bars are 95 percent LCL and UCL.

A)



B)



Literature Cited

Adkins, J.Y. and D.D. Roby... 2010. A status assessment of the double-crested cormorants (*Phalacrocorax auritus*) in western North America: 1998-2009.Final Report to the U.S. Army Corps of Engineers. Available on-line at www.birdresearchnw.org.

Adkins, J. Y., D. D. Roby, D. E. Lyons, K. N. Courtot, K. Collis, H. R. Carter, W. D Shuford, and P. J. Capitolo. *In press.* Estimated population size, trends, and limiting factors for the Double-crested Cormorant in western North America. Journal of Wildlife Management (accepted 2014).

Blackwell, B. F., M. A. Stapanian, and D. C. Weseloh. 2002. Dynamics of the double-crested cormorant population on Lake Ontario. Wildl. Soc. Bull. 30:345–353.

Hatch, J.J, and D. V. Weseloh. 1999. Double-crested cormorant (*Phalacrocorax auritus*), the birds of North America online (A. Poole, Ed.). Ithaca, New York. Available at: http://bna.birds.cornell.edu/bna/species/441/articles/introduction

NOAA (NOAA Fisheries). 2014. Supplemental Consultation on Remand for Operation of the Federal Columbia River Power System, 11 Bureau of Reclamation Projects in the Columbia Basin and ESA Section 10(a)(I)(A) Permit for Juvenile Fish Transportation Program. National Marine Fisheries Service, Northwest Region 246 pages.

Roby, D. D., K. Collis and 27 co-authors. 2014. Research, monitoring and evaluation of avian predation on salmonid smolts in the lower and mid-Columbia River. Draft 2013 Annual Report to the Bonneville Power Administration and the U.S. Army Corp of Engineers. 102 pp plus figures and tables.

Tyson, L. A., J. L. Belant, F. J. Cuthbert, and D. V. Weseloh. 1997. Nesting populations of double-crested cormorants in the United States and Canada. Pages 17-25 In Symposium on Double-crested Cormorants: Population Status and Management Issues in the Midwest. USDA-APHIS Tech. Bull. No. 1879

USFWS (U. S. Fish and Wildlife Service). 2009. Final Environmental Assessment: Extended Management of Double-crested Cormorants under 50 CFR 21.47 and

21.48. U.S. Dept. of the Interior, USFWS, Div. of Migratory Bird Management, 4401 N. Fairfax Drive MBSP-4017, Arlington, VA 22203.

U.S. Fish and Wildlife Service (USFWS). 2014. Draft Environmental Assessment: Management of Double-crested Cormorants under 50 CFR 21.47 and 21.48. U.S. Dept. of the Interior, USFWS, Div. of Migratory Bird Management, 4401 N. Fairfax Drive MBSP-4017, Arlington, VA 22203; in cooperation with U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services.

Van Der Veen, H. E. 1973. Some aspects of the breeding biology and demography of the Double-crested Cormorants (Phalacrocorax auritus) of Mandarte Island. Ph.D. thesis. Zoologisch Laboratorium der Rijksuniversiteit te Groningen, Groningen.

Appendix F: Location and Size of DCCO Breeding Colonies in the Affected Environment

DCCO breeding colonies within the affected environment are shown in Figure F.1 and listed in Table F.1. Data came from two sources: 1) the Pacific Flyway Council (PFC) monitoring strategy for the western population of DCCOs (PFC 2013) and 2) the status assessment of the western population of DCCOs (Adkins and Roby 2010). Active colonies were defined differently and surveys efforts and areas were not comparable between the two data sources; thus, both are provided. PFC (2013) defined "active" as a breeding colony that contained ≥5 breeding pairs (BP) at least 1 time during 2008–2012. Adkins and Roby (2010) defined "active" as a breeding colony that contained ≥1 breeding pair at least 1 time during 1998–2009.

In Figure F.1, colonies identified as active from both data sources are shown as a PFC (2013) colonies. In Table F.1, for PFC (2013) active colonies, the number of breeding pairs from the most recent survey during 2008–2012 is provided; for Adkins and Roby (2010), the maximum number of breeding pairs documented for a given year during 1998–2009 is provided. In total, 94 colonies were identified as active in both PFC (2013) and Adkins and Roby (2010); in addition, there were 30 active colonies exclusive to PFC (2013) and 67 active colonies exclusive to Adkins and Roby (2010). Thus, PFC (2013) and Adkins and Roby (2010) identified 124 and 161 active colonies, respectively, and there were 191 active colonies in total from both sources combined.

Figure F-1. DCCO Colonies in Affected Environment

Table F.1 List of DCCO colonies in the Affected Environment

Colony	PFC 2013				Adkins and Roby 2010	
	Active	MRS Year 2008-2012	Most Recent Survey # Breeding Pairs 2008-2012		Active	Max # Breeding Pairs 1998-2009
BRITISH COLUMBIA						
Gulf Islands						
Bare Point					X	19
Five Finger Island					X	43
Gabriola Cliffs	X	2009	43		X	95
Galiano Island cliffs	X	2009	47		X	90
Great Chain Island					X	300
Ladysmith Harbor					X	7
Mandarte Island	X	2009	143		X	225
Rose Islets					X	15
Shoal Island	X	2009	83		X	104
Interior						
Creston Valley WMA	X	2008	98		X	98
Northern Strait of Georgia						
Christie Islet					X	42
McRae Islets					X	1
Mitlenatch Island	X	2009	20		X	70
Pam Rock					X	4
Vancouver Area						
Sand Heads					X	35
Second Narrows Bridge Power Tower	X	2009	63		X	63
Westshore Terminal					X	11
CALIFORNIA						
Central Coast - Outer Coast North						
South Farallon Islands	X	2008	334		X	439
Central Coast - San Francisco Bay						
Alviso A18	X	2011	22			
Alviso Plant, Ponds A9 & A10	X	2011	130		X	75
Bair Island/Steinberger Slough Power Towers	X	2011	136		X	325
Cut off Slough (Bohannon)	X	2011	158			
Dumbarton Bridge Power Towers	X	2011	51		X	160
Greco Island Power Towers					X	62
Knight Island	X	2008	37		X	200

	PFC 2013				Adkins and Roby 2010	
Colony	Active	MRS Year 2008-2012	Most Recent Survey # Breeding Pairs 2008-2012		Active	Max # Breeding Pairs 1998-2009
Lake Merced	X	2011	129		X	319
Lake Merritt	X	2011	87		X	158
Moffett B2	X	2011	12			
Moffett Power Towers	X	2011	15		X	65
N. San Pablo Bay Radar Target	X	2008	15		X	15
N.E. San Pablo Bay Beacon					X	4
Richmond-San Rafael Bridge	X	2009	169		X	669
Russ Island	X	2011	33		X	38
San Francisco-Oakland Bay Bridge	X	2009	83		X	814
San Mateo Bridge & PG&E Towers					X	105
Spoonbill (Chipps Island)	X	2011	25			
Wheeler Island	X	2011	80		X	126
Interior						
American River, Mississippi Bar	X	2011	37			
Arroyo del Valle, Shadow Cliffs Park	X	2011	23		X	23
Beaver Lake					X	16
Butte Creek, Howard Slough	X	2011	5			
Butte Sink, confluence Butte Creek and Angel Slough	X	2011	100			
Butte Sink, North Butte Country Club					X	109
Butte Valley Reservoir	X	2009	11		X	24
Butte Valley WA, Meiss Lake	X	2011	35		X	84
Chiles Creek	X	2011	10			
Clear Lake	X	2011	53		X	57
Clear Lake NWR	X	2011	95		X	126
Delta Pond	X	2011	27			
Eagle Lake, island between Buck Pt. and Little Troxel Pt.					X	2
Eagle Lake, Pelican Point					X	118
Eucalyptus Island	X	2011	27			
Gray Lodge 1	X	2011	19			
Laguna de Santa Rosa					X	59
Lake Almanor, Almanor Peninsula	X	2011	15			
Lake Shastina	X	2009	41		X	41
Llanco Seco Rancho (Sac. River E)	X	2011	33		X	61
NNE Grimes (Sac. River W)					X	1
North Stone Lake, Stone Lakes NWR					X	180
Pellandini Ranch					X	38
Petaluma Waste Water Treatment Plant					X	6
Port of Sacramento					X	5

	PFC 2013				Adkins and Roby 2010	
Colony	**Active**	**MRS Year 2008-2012**	**Most Recent Survey # Breeding Pairs 2008-2012**		**Active**	**Max # Breeding Pairs 1998-2009**
San Joaquin River NWR, Christman Island					X	34
San Joaquin River NWR, Gardner's Cove					X	6
Sheepy Lake, Lower Klamath NWR	X	2011	55		X	458
Sutter Bypass West					X	12
Tule Lake NWR, Lower Sump					X	172
Tule Lake NWR, Upper Sump					X	56
Valensin Ranch, Cosumnes R. Reservoir					X	3
Venice Tip					X	9
Northern Coast - North Section						
Arcata Bay Sand Islands	X	2008	103		X	809
Big Lagoon	X	2008	42		X	42
Castle Rock	X	2008	35		X	84
False Cape Rocks					X	52
False Klamath Rock	X	2008	48		X	68
Little River Rock	X	2008	100		X	141
Old Arcata Wharf	X	2008	51		X	70
Prince Island	X	2008	220		X	323
Radar Station Rocks	X	2008	57		X	72
Sea Gull Rock	X	2008	13		X	21
Sea Lion Rock					X	20
Sugarloaf Island	X	2008	69		X	69
Teal Island	X	2008	485		X	485
Trinidad Bay Rocks	X	2008	5		X	5
White Rock	X	2008	6		X	33
Northern Coast - South Section						
Dillon Beach Rocks					X	16
Gull Rock					X	34
Hog Island	X	2011	548		X	285
Mendocino, Big River	X	2011	12			
Russian Gulch	X	2008	50		X	50
Russian River Rocks	X	2008	25		X	108
Shell-Wright Beach Rocks	X	2008	30		X	30
OREGON						
Central Coast						
Blast Rock	X	2009	12		X	50
Heceta Head	X	2012	12			
Parrot Rock	X	2009	19		X	19

	PFC 2013				Adkins and Roby 2010	
Colony	**Active**	**MRS Year 2008-2012**	**Most Recent Survey # Breeding Pairs 2008-2012**		**Active**	**Max # Breeding Pairs 1998-2009**
Unnamed Colony					X	4
Yaquina Bay Bridge					X	2
Columbia River Estuary						
Astoria-Megler Bridge	X	2011	60		X	24
Desdemona Sands Pilings					X	120
East Sand Island	X	2011	13045		X	13771
Miller Sands Navigational Aids	X	2009	162		X	208
Miller Sands Spit	X	2011	248		X	129
Other upper estuary Navigational Aids	X	2009	73		X	73
Rice Island					X	795
Interior						
Burns Gravel Ponds	X	2011	5			
Carlon Ranch	X	2011	7			
Crane Prairie Reservoir	X	2011	39		X	61
Crump Lake, Tern Island					X	10
Dog Lake	X	2011	15			
Drews Reservoir	X	2011	15			
Gerber Reservoir					X	6
Gosling Island, Snake River Sector, Deer Flat NWR	X	2009	25		X	25
Howard Prairie Lake	X	2011	8			
Hyatt Lake	X	2011	26			
Malheur Lake	X	2011	140		X	259
Malheur NWR, Frenchglen Area, Baca Lake	X	2011	10			
Malheur NWR, Sodhouse Ranch	X	2011	140		X	29
Pelican Lake, Pelican Island	X	2011	38		X	36
Rivers End (Lake Abert)	X	2011	11		X	16
Snake River Unnamed Island (1)	X	2009	27		X	27
Snake River Unnamed Island (2)	X	2009	63		X	63
Summer Lake, Unnamed Island					X	36
Swan Lake	X	2011	8		X	60
Upper Klamath Lake	X	2011	250		X	1270
Yonna Valley, Alkali Lake	X	2011	5			
Northern Coast						
Haystack Rock	X	2009	75		X	107
Three Arch Rocks, Finley Rock (East)	X	2009	417		X	417
Three Arch Rocks, Middle Rock (Middle)	X	2009	22		X	22
Unnamed Colony (Cape Lookout)	X	2009	128		X	132
Unnamed Colony (Oswald West)	X	2009	95		X	219

	PFC 2013				Adkins and Roby 2010	
Colony	**Active**	**MRS Year 2008-2012**	**Most Recent Survey # Breeding Pairs 2008-2012**		**Active**	**Max # Breeding Pairs 1998-2009**
Southern Coast						
Bolon Island	X	2009	763		X	763
Castle Rock	X	2009	15		X	141
Chiefs Island (Gregory Point)	X	2009	88		X	8
Coos Bay, Coos River (Chandler Bridge)	X	2011	40			
Elephant Rock					X	1
Gull Rock					X	27
Hunters Island	X	2009	222		X	297
North Crook Point Rock					X	8
Qochyax (Squaw) Island	X	2009	26		X	107
Rainbow Island					X	1
Redfish Rocks	X	2009	6		X	6
Sisters Rocks Island	X	2009	49		X	49
Siuslaw River Trees					X	144
Sunset Bay	X	2011	28			
Table Rock	X	2009	125		X	125
Unnamed Colony (Mack Reef 1)	X	2009	24		X	24
Unnamed Colony (Mack Reef 2)	X	2009	14		X	14
Unnamed Colony (OR South Unnamed Rock)					X	1
Unnamed Colony (OR Southern Coast 1)					X	163
Unnamed Colony (OR Southern Coast 2)	X	2009	56		X	145
Unnamed Colony (OR Southern Coast 3)	X	2011	183		X	183
Unnamed Colony (OR Southern Coast 4)					X	88
Whaleshead Cove (East Rock)	X	2009	17		X	17
Whaleshead Cove (West Rock)					X	17
WASHINGTON						
Columbia River Estuary						
Navigational Markers					X	70
Eastern Strait of Juan de Fuca						
Minor Island	X	2012	25			
Protection Island					X	86
Smith Island	X	2009	28		X	95
Grays Harbor						
Grays Harbor Channel Markers	X	2011	137		X	185
Unnamed Sand Island					X	5
Interior						

	PFC 2013				Adkins and Roby 2010	
Colony	**Active**	**MRS Year 2008-2012**	**Most Recent Survey # Breeding Pairs 2008-2012**		**Active**	**Max # Breeding Pairs 1998-2009**
Foundation Island	X	2011	318		X	359
Hanford Reach					X	8
Lions Ferry Railroad Trestle					X	2
Lower Turnbull Slough NWR	X	2012	27			
Miller Rocks					X	5
Mouth of Okanogan River	X	2011	32		X	38
North Potholes	X	2011	900		X	1156
Pend Oreille River, Kent Creek (Greggs Addition)	X	2011	14			
Pend Oreille River, Usk Bridge	X	2011	146			
Sprague Lake, Harper Island	X	2011	107		X	42
Olympic Peninsula Outer Coast						
Bodelteh Islands					X	3
Carroll Islands					X	65
Ghost Rock					X	1
Gunsight Rock					X	4
Hoh Head Mainland					X	68
Little Hogsback Island	X	2009	71		X	71
North Rock					X	31
Petrel Island (Kohchaa)					X	11
Point Grenville Islands					X	39
Tunnel Islands					X	40
White Rock (Olympic)					X	7
Willoughby Rock					X	1
Puget Sound						
Henderson Inlet, Woodard Bay	X	2012	150			
San Juan Islands						
Bird Rocks	X	2012	155		X	148
Drayton Harbor	X	2009	142		X	142
Goose Island (Cattle Pass)	X	2009	56		X	84
Gull Rock	X	2009	27			
Hall Island	X	2011	13		X	14
Snohomish River Mouth	X	2009	249		X	529
Viti Rocks	X	2012	50		X	47
Williamson Rocks	X	2010	5		X	63

Appendix G: List of Birds Observed on East Sand Island March-June 2013

Observations of Birds on East Sand Island 2013	
Common Name	***Scientific Name***
LOONS and GREBES	
Pacific Loon	*Gavia pacifica*
Common Loon	*Gavia immer*
Horned Grebe	*Podiceps auritus*
Eared Grebe	*Podiceps nigricollis*
Western Grebe	*Aechmophorus occidentalis*
SEABIRDS, DUCKS	
Sooty Shearwater	*Puffinus griseus*
Pigeon Guillemot	*Cepphus columba*
Common Murre	*Uria aalge*
Surf Scoter	*Melanitta perspicillata*
White-winged Scoter	*Melanitta fusca*
Long-tailed Duck	*Clangula hyemalis*
OSPREY, EAGLES, FALCONS, VULTURES	
Osprey	*Pandion haliaetus*
Bald Eagle	*Haliaeetus leucocephalus*
Peregrine Falcon	*Falco peregrinus*
Turkey Vulture	*Cathartes aura*
Northern Harrier	*Circus cyaneus*
WATERFOWL	
Greater White-fronted Goose	*Anser albifrons*
Brant	*Branta bernicia*
Cackling Goose	*Branta hutchinsii*
Canada Goose	*Branta canadensis*
Gadwall	*Anas strepera*
American Wigeon	*Anas americana*
Mallard	*Anas platyrhynchos*
Blue-winged Teal	*Anas discors*
Northern Shoveler	*Anas clypeata*
Northern Pintail	*Anas acuta*
Green-winged Teal	*Anas crecca*
Greater Scaup	*Aythya marila*
Lesser Scaup	*Aythya affinis*
Harlequin Duck	*Histrionicus histrionicus*
Bufflehead	*Bucephala albeola*
Common Goldeneye	*Bucephala clangula*

Observations of Birds on East Sand Island 2013	
Common Name	***Scientific Name***
Hooded Merganser	*Lophodytes cucullatus*
PELICANS AND CORMORANTS	
American White Pelican	*Pelacanus erythrorhynchos*
Brown Pelican	*Pelicanus occidentalis*
Brandt's Cormorant	*Phalacrocorax penicillatus*
Double-crested Cormorant	*Phalacrocorax auritus*
Pelagic Cormorant	*Phalacrocorax pelagicus*
GALLINACEOUS BIRDS	
Bonaparte's Gull	*Xema sabini*
Mew Gull	*Larus canus*
Ring-billed Gull	*Larus delawarensis*
Western Gull	*Larus occidentalis*
Glaucous-winged Gull	*Larus glaucescens*
Glaucous-winged x Western (hybrid)	*Larus glaucescens x occidentalis*
Caspian Tern	*Hydroprogne caspia*
HERONS	
Great Blue Heron	*Ardea herodias*
PLOVERS, SANDPIPERS, SHOREBIRDS	
Black-bellied Plover	*Pluvialis squatarola*
Semipalmated Plover	*Charadrius semipalmatus*
Spotted Sandpiper	*Actitis macularia*
Least Sandpiper	*Calidris minutilla*
Western Sandpiper	*Calidris mauri*
Greater Yellowlegs	*Tringa meanoleuca*
Willet	*Tringa semipalmata*
Whimbrel	*Numenius phaeopus*
Marbled Godwit	*Limosa fedoa*
Black Turnstone	*Aremaria melanocephala*
Red Knot	*Calidris canutus*
Sanderling	*Calidris alba*
Dunlin	*Calidris alpina*
Short-billed Dowitcher	*Limnodromus griseus*
Long-billed Dowitcher	*Limnodromus scolopaceus*
Red-necked Phalarope	*Phalaropus lobatus*
DOVES	
Rock Dove	*Columba livia*
Eurasian Collared-Dove	*Streptopelia decaocto*
RAVENS / CROWS	

Observations of Birds on East Sand Island 2013	
Common Name	***Scientific Name***
American Crow	*Corvus brachyrhynchos*
Common Raven	*Corvus corvax*
SWALLOWS	
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*
Tree Swallow	*Tachycineta bicolor*
Violet-green Swallow	*Tachycineta thalassina*
Barn Swallow	*Hirundo rustica*
TOWHEES AND SPARROWS	
Spotted Towhee	*Pipilo maculatus*
Golden-crowned Sparrow	*Zonotrichia atricapilla*
Song Sparrow	*Melospiza melodia*
Savannah Sparrow	*Passerculus sandwichensis*
BLACKBIRDS AND STARLINGS	
Brewer's Blackbird	*Euphagus cyanocephalus*
European Starling	*Sturnus vulgaris*
WRENS AND THRUSHES	
Bewick's Wren	*Thryomanes bewickii*
Swainson's Thrush	*Catharus ustulatus*
Hermit Thrush	*Catharus guttatus*
American Robin	*Turdus migratorius*
American Pipit	*Anthus rubescens*
HUMMINGBIRDS, WARBLERS, FINCHES	
Yellow Warbler	*Dendroica petechia*
Rufous Hummingbird	*Selasphorus rufus*
American Goldfinch	*Caduelis tristis*

Appendix H: Federally Listed Threatened and Endangered Species Occurring in the Affected Environment

Table H.1 provides a list of ESA-listed fishes (as of 1 February 2014) that are potential prey for DCCOs in the affected environment Location of origin and status (threatened {T}, endangered {E}), along with a web link to additional information, is provided for each species. Inclusion of an ESA-listed fish species was based solely on the geographic location of the species in the affected environment, with no attempt made to evaluate the likelihood of DCCO depredation. Critical habitat maps were not available for all species, and, for these species, possible occurrence was evaluated based on species distribution descriptions and other sources of information provided by the listing agency. Effects to listed species within the sub-regions of the affected environment from the proposed alternatives are addressed in Chapters 4.

Table H-1 ESA-Listed Fish in Affected Environment

Common Name	Scientific Name	Location (status)	Link	Critical Habitat	Critical Habitat Mapped
Bocaccio	Sebastes paucispinis	Puget Sound/Georgia Basin (E)	http://www.nmfs.noaa.gov/pr/species/fish/	Yes	Yes
Borax chub	Gila boraxobius	Wherever found (E)	http://www.fws.gov/species/#endangered	Yes	Yes
Bull Trout	Salvelinus confluentus	Contiguous United States (T)	http://www.fws.gov/species/#endangered	Yes	Yes
Canary Rockfish	Sebastes pinniger	Puget Sound/Georgia Basin (T)	http://www.nmfs.noaa.gov/pr/species/fish/	Yes	Yes
Chinook Salmon	Oncorhynchus tshawytscha	Puget Sound (T)	http://www.nmfs.noaa.gov/pr/species/fish/	Yes	Yes
Chinook Salmon	Oncorhynchus tshawytscha	Upper Willamette River (T)	http://www.nmfs.noaa.gov/pr/species/fish/	Yes	Yes
Chinook Salmon	Oncorhynchus tshawytscha	Lower Columbia River (T)	http://www.nmfs.noaa.gov/pr/species/fish/	Yes	Yes
Chinook Salmon	Oncorhynchus tshawytscha	Upper Columbia River spring-run (E)	http://www.nmfs.noaa.gov/pr/species/fish/	Yes	Yes
Chinook Salmon	Oncorhynchus tshawytscha	Snake River fall-run (T)	http://www.nmfs.noaa.gov/pr/species/fish/	Yes	No
Chinook Salmon	Oncorhynchus tshawytscha	Snake River spring/summer-run (T)	http://www.nmfs.noaa.gov/pr/species/fish/	Yes	No
Chinook Salmon	Oncorhynchus tshawytscha	California Coast (T)	http://www.nmfs.noaa.gov/pr/species/fish/	Yes	Yes
Chinook Salmon	Oncorhynchus tshawytscha	Central Valley spring-run (T)	http://www.nmfs.noaa.gov/pr/species/fish/	Yes	Yes
Chinook Salmon	Oncorhynchus tshawytscha	Sacramento winter-run (E)	http://www.nmfs.noaa.gov/pr/species/fish/	Yes	No
Chum Salmon	Oncorhynchus keta	Hood Canal (T)	http://www.nmfs.noaa.gov/pr/species/fish/	Yes	Yes
Chum Salmon	Oncorhynchus keta	Columbia River (T)	http://www.nmfs.noaa.gov/pr/species/fish/	Yes	Yes
Coho Salmon	Oncorhynchus kisutch	Lower Columbia River (T)	http://www.nmfs.noaa.gov/pr/species/fish/	Yes	No
Coho Salmon	Oncorhynchus kisutch	Oregon Coast (T)	http://www.nmfs.noaa.gov/pr/species/fish/	Yes	Yes
Coho Salmon	Oncorhynchus kisutch	Southern Oregon/Northern	http://www.nmfs.noaa.gov/pr/species/fish/	Yes	No

Common Name	Scientific Name	Location (status)	Link	Critical Habitat	Critical Habitat Mapped
		California (T)			
Coho Salmon	Oncorhynchus kisutch	Central California Coast (E)	http://www.nmfs.noaa.gov/pr/species/fish/	Yes	No
Delta Smelt	Hypomesus transpacificus	Wherever found (T)	http://www.fws.gov/species/#endangered	Yes	Yes
Foskett Speckled Dace	Rhinichthys osculus ssp	Wherever found (T)	http://www.fws.gov/species/#endangered	No	No
Green Sturgeon	Acipenser medirostris	Pacific Southern (T)	http://www.nmfs.noaa.gov/pr/species/fish/	Yes	Yes
Hutton tui chub	Gila bicolor	Wherever found (T)	http://www.fws.gov/species/#endangered	No	No
Lahontan Cutthroat Trout	Oncorhynchus clarki henshawi	Wherever found (T)	http://www.fws.gov/species/#endangered	No	No
Lost River Sucker	Deltistes luxatus	Wherever found (E)	http://www.fws.gov/species/#endangered	Yes	Yes
Modoc Sucker	Catostomus microps	Wherever found (E)	http://www.fws.gov/species/#endangered	Yes	Yes
Owens pupfish	Cyprinodon radiosus	wherever found (E)	http://www.fws.gov/species/#endangered	No	No
Oregon chub	Oregonichthys crameri	Wherever found (T)	http://www.fws.gov/species/#endangered	Yes	No
Pacific Eulachon	Thaleichthys pacificus	Southern (T)	http://www.nmfs.noaa.gov/pr/species/fish/	Yes	Yes
Paiute cutthroat trout	Oncorhynchus clarkii seleniris	Wherever found (T)	http://www.fws.gov/species/#endangered	No	No
Shortnose Sucker	Chasmistes brevirostris	Wherever found (E)	http://www.fws.gov/species/#endangered	Yes	Yes
Sockeye Salmon	Oncorhynchus nerka	Snake River (E)	http://www.nmfs.noaa.gov/pr/species/fish/	Yes	No
Sockeye Salmon	Oncorhynchus nerka	Ozette Lake (T)	http://www.nmfs.noaa.gov/pr/species/fish/	Yes	Yes
Steelhead	Oncorhynchus mykiss	Puget Sound (T)	http://www.nmfs.noaa.gov/pr/species/fish/	Yes	No
Steelhead	Oncorhynchus mykiss	Upper Willamette River (T)	http://www.nmfs.noaa.gov/pr/species/fish/	Yes	Yes
Steelhead	Oncorhynchus mykiss	Lower Columbia River (T)	http://www.nmfs.noaa.gov/pr/species/fish/	Yes	Yes
Steelhead	Oncorhynchus mykiss	Middle Columbia River (T)	http://www.nmfs.noaa.gov/pr/species/fish/	Yes	Yes
Steelhead	Oncorhynchus mykiss	Upper Columbia River (T)	http://www.nmfs.noaa.gov/pr/species/fish/	Yes	Yes
Steelhead	Oncorhynchus mykiss	Snake River (T)	http://www.nmfs.noaa.gov/pr/species/fish/	Yes	Yes
Steelhead	Oncorhynchus mykiss	Northern California (T)	http://www.nmfs.noaa.gov/pr/species/fish/	Yes	Yes
Steelhead	Oncorhynchus mykiss	Central California Coast (T)	http://www.nmfs.noaa.gov/pr/species/fish/	Yes	Yes
Steelhead	Oncorhynchus mykiss	California Central Valley (T)	http://www.nmfs.noaa.gov/pr/species/fish/	Yes	Yes
Tidewater Goby	Eucyclogobius newberryi	Wherever found (E)	http://www.fws.gov/species/#endangered	Yes	Yes

Common Name	Scientific Name	Location (status)	Link	Critical Habitat	Critical Habitat Mapped
Warner Sucker	Catostomus warnerensis	Wherever found (T)	http://www.fws.gov/species/#endangered	Yes	Yes
Yelloweye Rockfish	Sebastes ruberrimus	Puget Sound/Georgia Basin (T)	http://www.nmfs.noaa.gov/pr/species/fish/	Yes	Yes

Fish of conservation concern (as of 1 February 2014) to the U.S. Government in the affected environment are identified in Table H-2. The location of origin and status (species of concern {S}, ESA candidate {C}), along with a web link to additional information, is provided for each species. Inclusion of fish was based solely on the geographic location of the species in the affected environment, with no attempt made to evaluate the likelihood of DCCO predation. There is no designated critical habitat for fish of federal conservation concern (candidate species) because habitat is not officially designated until the species is ESA-listed. As such, possible occurrence was evaluated based on species distribution descriptions and other sources of information provided by the listing agency. Pelagic shark species were not included due to a lack of geographic distribution information.

Table H-2 Fish of Conservation Concern to Federal Government

Common Name	Scientific Name	Location (status)	Link
Bocaccio	*Sebastes paucispinis*	Pacific-Southern (S)	http://www.nmfs.noaa.gov/pr/species/fish/
Chinook Salmon	*Oncorhynchus tshawytscha*	Central Valley Fall and Late Fall (S)	http://www.nmfs.noaa.gov/pr/species/fish/
Chinook Salmon	*Oncorhynchus tshawytscha*	Upper Klamath and Trinity River Basin (C)	http://www.nmfs.noaa.gov/pr/species/fish/
Coho Salmon	*Oncorhynchus kisutch*	Puget Sound/Strait of Georgia (S)	http://www.nmfs.noaa.gov/pr/species/fish/
Cowcod	*Sebastes levis*	Central Oregon to central Baja California (S)	http://www.nmfs.noaa.gov/pr/species/fish/
Green Sturgeon	*Acipenser medirostris*	Pacific Northern (S)	http://www.nmfs.noaa.gov/pr/species/fish/
Pacific cod	*Gadus macrocephalus*	Salish Sea (S)	http://www.nmfs.noaa.gov/pr/species/fish/
Pacific hake	*Merluccius productus*	Pacific - Georgia (S)	http://www.nmfs.noaa.gov/pr/species/fish/
Longfin smelt	*Spirinchus thaleichthys*	Wherever found (C)	http://ecos.fws.gov/tess_public/pub/SpeciesReport.do?listingType=C&mapstatus=1
Steelhead	*Oncorhynchus mykiss*	Oregon Coast (S)	http://www.nmfs.noaa.gov/pr/species/fish/

Other non-fish species of conservation concern (proposed [P], candidate [C], threatened [T], or endangered [E]) within the affected environment, the sub-regions of the affected environment, and the Columbia River Estuary are identified in Table H-3. Species lists were obtained from the USFWS's Information, Planning, and Conservation (IPaC) System and include species identified in the IPaC report that should be considered given the geographic boundary of the project. Inclusion of species was based solely on the geographic location of the species with no attempt to evaluate the likelihood of conflict from EIS actions. Species with designated critical habitat are noted and additional information for each species can be found at: http://www.fws.gov/species/#endangered.

Table H-3. Non-fish ESA-listed species within the Affected Environment, sub-regions and the Columbia River Estuary.

Common Name	Scientific Name	Population (if designated)	Status	Affected Environment	Sub-Regions	Columbia River Estuary	Critical Habitat	Critical Habitat Mapped
AMPHIBIANS								
California red-legged frog	*Rana draytonii*	Entire	T	X			Y	Y
Columbia Spotted frog	*Rana luteiventris*	Great Basin DPS	C	X				
Mountain Yellow-Legged frog	*Rana muscosa*	U.S.A., N of Tehachapi Mts; southern California DPS	PE; E	X			Y	Y
Oregon Spotted frog	*Rana pretiosa*		PT	X	X	X		
Yosemite toad	*Anaxyrus canorus*		PT	X				
BIRDS								
Greater sage-grouse	*Centrocercus urophasianus*	Bi-state; Columbia basin DPS; Entire	PT; C; C	X	X (CB DPS)			
Least Bell's vireo	*Vireo bellii pusillus)*	Entire	E	X			Y	Y
Marbled murrelet	*Brachyramphus marmoratus*	CA, OR, WA	T	X	X	X	Y	Y
Northern Spotted owl	*Strix occidentalis caurina*	Entire	T	X	X	X	Y	Y
Short-Tailed albatross	*Phoebastria (=diomedea) albatrus)*	Entire	E	X	X	X		
Southwestern Willow flycatcher	*Empidonax traillii extimus*	Entire	E	X			Y	Y
Streaked Horned lark	*Eremophila alpestris strigata*		T	X	X	X	Y	Y
Western snowy plover	*Charadrius nivosus ssp. Nivosus*	Pacific coastal pop.	T	X	X	X	Y	Y
Yellow-Billed Cuckoo	*Coccyzus americanus*	Western U.S. DPS	PT	X	X	X		
CRUSTACEANS								
Vernal Pool fairy shrimp	*Branchinecta lynchi*	Entire	T	X			Y	Y

Common Name	Scientific Name	Population (if designated)	Status	Affected Environment	Sub-Regions	Columbia River Estuary	Critical Habitat	Critical Habitat Mapped
PLANTS								
Whitebark pine	*Pinus albicaulis*		C	X	X	X		
Applegate's milk-vetch	*Astragalus applegatei*		E	X				
Beach layia	*Layia carnosa*		E	X				
Bradshaw's desert-parsley	*Lomatium bradshawii*		E	X	X	X		
Burke's goldfields	*Lasthenia burkei*		E	X				
Contra Costa goldfields	*Lasthenia conjugens*		E	X			Y	Y
Cook's lomatium	*Lomatium cookii*		E	X			Y	Y
Gentner's Fritillary	*Fritillaria gentneri*		E	X				
Golden paintbrush	*Castilleja levisecta*		T	X	X	X		
Howell's spectacular thelypody	*Thelypodium howellii spectabilis*		T	X				
Howell's spineflower	*Chorizanthe howellii*		E	X				
Kincaid's lupine	*Lupinus sulphureus ssp. kincaidii*		T	X	X	X	Y	Y
Kneeland Prairie penny-cress	*Thlaspi californicum*		E	X			Y	Y
Large-flowered woolly Meadowfoam	*Limnanthes floccosa ssp. Grandiflora*		E	X			Y	Y
Macfarlane's four-o'clock	*Mirabilis macfarlanei*		T	X				
Malheur wire-lettuce	*Stephanomeria malheurensis*		E	X			Y	Y
Marsh Sandwort	*Arenaria paludicola*		E	X	X			
McDonald's rock-cress	*Arabis macdonaldiana*		E	X				
Menzies' wallflower	*Erysimum menziesii*		E	X				
Monterey clover	*Trifolium trichocalyx*		E	X				
Nelson's checker-mallow	*Sidalcea nelsoniana*		T	X	X	X		
Northern Wormwood	*Artemisia campestris var. wormskioldii*		C	X	X			
Red Mountain buckwheat	*Eriogonum kelloggii*		C	X				
Red Mountain stonecrop	*Sedum eastwoodiae*		C	X				
Rough popcornflower	*Plagiobothrys hirtus*		E	X	X			
Showy stickseed	*Hackelia venusta*		E	X				
Siskiyou Mariposa lily	*Calochortus persistens*		C	X				
Slender Orcutt grass	*Orcuttia tenuis*		T	X			Y	Y
Spalding's Catchfly	*Silene spaldingii*		T	X				
Tahoe Yellow cress	*Rorippa subumbellata*		C	X				

Common Name	Scientific Name	Population (if designated)	Status	Affected Environment	Sub-Regions	Columbia River Estuary	Critical Habitat	Critical Habitat Mapped
Umtanum Desert buckwheat	*Eriogonum codium*		T	X				
Ute ladies'-tresses	*Spiranthes diluvialis*		T	X	X			
Water howellia	*Howellia aquatilis*		T	X	X	X		
Webber Ivesia	*Ivesia webberi*		PT	X				
Wenatchee Mountains checkermallow	*Sidalcea oregana var. calva*		E	X			Y	Y
Western lily	*Lilium occidentale*		E	X	X			
White Bluffs bladderpod	*Physaria douglasii ssp. Tuplashensis*		T	X				
Willamette daisy	*Erigeron decumbens var. decumbens*		E	X	X	X	Y	Y
INSECTS								
Behren's Silverspot butterfly	*Speyeria zerene behrensii*	Entire	E	X				
Carson wandering skipper	*Pseudocopaeodes eunus obscurus*	U.S.A. (NV, CA)	E	X				
Fender's Blue butterfly	*Icaricia icarioides fenderi*		E	X	X		Y	Y
Lotis Blue butterfly	*Lycaeides argyrognomon lotis*	Entire	E	X				
Oregon Silverspot butterfly	*Speyeria zerene hippolyta*	Entire	T	X	X	X	Y	Y
Taylor's Checkerspot	*Euphydryas editha taylori*		E	X	X		Y	Y
MAMMALS								
Canada Lynx	*Lynx canadensis*	Contiguous U.S. DPS	T	X	X	X	Y	Y
Columbian White-Tailed deer	*Odocoileus virginianus leucurus*	Columbia River DPS	E	X	X	X		
Fisher	*Martes pennanti*	West Coast DPS (OR)	C	X	X	X		
Gray wolf	*Canis lupus*	USA (WA, OR, CA)	E	X	X	X		
Grizzly bear	*Ursus arctos horribilis*	Lower 48	T	X	X			
North American wolverine	*Gulo gulo luscus*		PT	X	X	X		
Olympia pocket gopher	*Thomomys mazama pugetensis*		PT	X	X			
Point Arena mountain beaver	*Aplodontia rufa nigra*	Entire	E	X				
Pygmy Rabbit	*Brachylagus idahoensis*	Columbia Basin DPS	E	X				
Red tree vole	*Arborimus longicaudus*	North Oregon Coast DPS	C	X	X	X		
Roy Prairie pocket gopher	*Thomomys mazama glacialis*		PT	X	X			
Sierra Nevada Bighorn sheep	*Ovis canadensis sierrae*	Sierra Nevada	E	X			Y	Y
Tenino pocket gopher	*Thomomys mazama tumuli*		PT	X	X			

Common Name	Scientific Name	Population (if designated)	Status	Affected Environment	Sub-Regions	Columbia River Estuary	Critical Habitat	Critical Habitat Mapped
Washington ground squirrel	*Urocitellus washingtoni*		C	X				
Woodland caribou	*Rangifer tarandus caribou*	Selkirk Mountain population	E	X			Y	Y
Yelm pocket gopher	*Thomomys mazama yelmensis*		PT	X	X			
REPTILES								
Green sea turtle	*Chelonia mydas*	except where endangered	T	X	X	X	Y	Y
Leatherback sea turtle	*Dermochelys coriacea*	Entire	E	X	X	X	Y	Y
Loggerhead sea turtle	*Caretta caretta*	North Pacific Ocean DPS	E	X	X	X		
Olive Ridley sea turtle	*Lepidochelys olivacea*	except where endangered	T	X	X	X		

Appendix I: Economic Analysis for In-River Columbia River Fisheries

Executive Summary

This report provides a description of Columbia River Basin in-river fisheries related economic effects and social implications that result from reducing predation on juvenile salmon and steelhead stocks by double-crested cormorant (DCCO) colony residing on East Island located in the Columbia River estuary. Columbia River in-river fisheries are defined as the regions wherever Columbia River Basin production contributes to in-river fisheries, which include the Columbia Basin ecological provinces for the Columbia Estuary, Lower Columbia, Columbia Gorge, Columbia Plateau, Columbia Cascade, Blue Mountain, and Mountain Snake (see Figure 2). A deterministic simulation model was developed for showing relative effects between adopted status quo conditions and two DCCO management plan alternatives. Existing economic models were used to translate the saved outmigrating smolts survival to in-river fisheries economic impacts. The report also has brief descriptions of social implications for increasing harvest opportunities due to lowering juvenile salmonid predation. The report content poses but does not answer the question about causing other environmental burdens and benefits from carrying out the management plan alternatives. Sections of this report will be incorporated into NEPA documentation being prepared for the DCCO management plan in the spring 2014.

Economic analysis measurements are offered for fishing industry participant (including commercial non-Indian and tribal, and recreational sectors) direct financial value (DFV), and regional economic impacts (REI) from the "use" of salmon and steelhead fish resources. This set of measurements is offered because they are the most understandable of economic metrics. There are other use and non-use economic metrics that could be developed. However, the measurements for such concepts as non-use existence value are abstract and less understood by non-technical audiences. It would be important to generate the additional metrics if there were to be tradeoff analysis for disparate actions, such as mitigating for DCCO unaltered predation with increased production from salmonid habitat improvements.[1] These

---

1. This report does not discuss an assessment for redirecting DCCO management plan funds in a manner that recovers and increases natural origin smolt production levels through other means, such as habitat enhancements, fish passage improvements (flow, water temperature, withdrawal, predation reduction), and adjustments to harvest management strategies (vessel and permit forbearance, harvest avoidance, selection), etc. (Of these other items, dealing with adjustments to harvest management is a difficult and complex task because of multiple and overlapping jurisdictions, but it is a necessary inclusion at some level of detail because of the connectiveness of any fish resource change.) Such tradeoff investigations should be done when

other metrics would provide a common unit to compare and contrast over time the impacts from the additional actions.[2,3]

The economic analysis geographic scope is to assess salmon and steelhead in-river fisheries positive impacts from the predation reduction on Columbia River Basin economies. This spatially limited economic analysis excludes showing positive impacts to other out-of-basin economies where Columbia River produced adult fish show up in fisheries. The limitations also preclude inclusion of externalities such as possible negative impacts to out-of-basin regions from a non-lethal displacement alternative. Research has shown that past DCCO dissuasion and dispersal techniques on the East Island colony have caused migration to northern Washington Coast and British Columbia estuaries. Of particular concern is whether the non-lethal alternatives would cause dispersal to upriver Columbia River locations as juvenile salmonid diet share increases due to the decreasing availability of marine and non-salmonid fish. The scope limitation also excluded the economic assessment of possible positive impacts from non-salmonid in-river fisheries.

While this report contains a rich set of quantifications, also much is written about methods that are used to arrive at results. Such discussions are needed because there are many unknowns and uncertainties in the inputs and behavior relationships built into the economic models. Definitions and focal modeling assumptions for the economic measurements are as follows.

- The participant ***DFV*** measurements are for revenue received by harvesters and processors, and expenditures made by recreational anglers that are linked with the availability of Columbia River Basin salmon and steelhead adult returns. Tribal

---

deciding on fish resource policies to show a broader perspective for decisions. This will ensure decisions are being made with visibility to cost effectiveness and economic efficiencies.

2. The other metrics could also be used in benefit-cost analysis (BCA) to show society level net economic benefits for the DCCO predation controls and judge which action or no-action might be most efficient. The BCA would rely on active and passive use net economic value (NEV) calculations. The active uses would be for such direct use activities like commercial and recreational fishing and indirect non-extractive uses like viewing birds. The passive use values are what society says they may pay for preserving wild fish runs. A cardinal dollar measure that society places on natural capital like bird populations and wild fish is subject to research conjecture, but comparative magnitudes can be revealing. The difficulty in undertaking BCA is deciding and defining what is a benefit and what is a cost. Just the explanation for trying to parameterize a BCA through such assignments can be informing to policy decision makers.
3. Sometimes cost-effectiveness analysis (CEA) is a desired public policy economic analysis metric when action objectives are clearly defined. For example, it might be of interest to know if DCCO management plan costs per juvenile salmonid saved is less or more than other passage survival improvement projects.

commercial harvest revenues are included in the calculations. A value for tribal ceremonial and subsistence harvests is not included. The calculations for revenue and first round spending measurements may give some information about revenue flows, but do not reflect total impacts on an economy nor do they reflect a dollar value that can be used to compare and contrast fish resource benefits.

- An ***REI*** analysis is provided to show significance of economic contributions to regional economies. The regional economies are within the Columbia River Basin where in-river fisheries occur. The measurement units are in personal income. The personal income measure can be interpreted to be household net earnings and a region's average household net earnings statistic can be used to translate the measure to an equivalent job metric. The measure uses the simplifying assumption that all fishing industry spending is afforded by money originating from outside the regions and that there are no substitution activities. Some of the recreational fishery related impacts could possibly have substitutions in other recreational activities, but there would be few substitutes to commercial fisheries, especially for in-river harvesting and its processing. The accounting stance is for state level economies. The REI results are itemized for the in-river fishery's sectors. The economic contributions include the "multiplier effect."[4]

The economic analysis is referenced to baseline conditions (referred to as the status quo alternative). The baseline conditions, economic analysis modeling exogenous variables, and management plan alternatives' specifications are shown in Table 1. Ecosystem feedback effects such as saved juvenile salmonid compensatory predation, varying outmigrating smolts other passage mortality, and differing ocean environment mortality were not incorporated into the economic analysis. The absolute value (rather than changed value) for the economic contributions could be a conservative or liberal estimate because the outmigrating smolt biomass subject to DCCO predation is an economic analysis intermediate calculated variable subject to many assumptions about all hydro system passage mortalities.

Hatchery production and release schedules are exogenous variables in the economic model. The releases are annual averages over a five year average period 2008-2012. There are two example changed conditions in hatchery production and practices that will not be reflected in economic analysis results. The first is pending staged shift in commercial non-Indian effort

4. The economic contribution calculations include not only the direct spending effects, but also the indirect and induced effects that follow. Economic input/output (I/O) models are used to estimate the downstream economic contributions which are sometimes called the multiplier effect or ripple effect.

from lower Columbia River mainstem to off-channel fishing areas. This regulatory action is to be accompanied with increased Youngs Bay select area smolt acclimation and release numbers. The second is the expected ramp-up in the Colville Tribal Nation Chief Joseph Hatchery production with releases in the Okanogan River area. Changed DCCO predation on outmigrating smolts from these two examples could have important subsequent economic effects on the associated in-river fisheries.

The calculation of economic effects is dependent on the highly variable smolt-to-adult survival rate (SAS). A SAS range can be 50 percent lower and 100 percent higher than what is assumed for baseline conditions. A SAS can be different for hatchery and wild origin production. The SAS is applied linearly to outmigrating smolt biomass, so its variance over the broodstock averaging period would directly show the variance in economic effects. Single point results are shown as if the ultimate effects from DCCO depredation actions were occurring in the present economy reflected by an adopted economic input-out model.

There certainly could be a different set of baseline conditions and variances thereof applied in wider scope economic analysis, but the interest is to find changed in-river fishery related economic contributions. Some of the different conditions and their uncertainties would be on both sides of the alternatives' consequence equation, and in effect, cancel out the additional and different detail. The model results are useful for showing the alternatives' magnitudes and direction of effects. However, the absolute results for the status quo and alternatives are stylized representations. Other studies should be consulted and relied upon for actual economic descriptions (such as the in-river fishing industry economic contributions) and biological descriptions (such as DCCO juvenile salmonid consumption).

An important assumption in the economic analysis is holding hatchery production constant for each of the alternatives. It is often overlooked in Pacific salmon fisheries' economic analysis the importance of economic contributions that come from operating fishery enhancement and supplementation hatcheries. Smolt production costs can range between $1 to $2 each depending on cost accounting inclusions. Production of fall Chinook subyearlings (released at 25 to 50 per pound and comprise about 50 percent of all releases) are lesser, and production of steelhead yearlings (released at eight to 12 per pound and comprise about 12 percent of all releases) are higher. If hatchery production funding is considered new money into a region, then the costs for labor, materials, administration, monitoring, and construction provide significant economic contributions particularly to rural economies where the hatcheries are located.

It could be that hatchery production can be throttled when there are returning hatchery origin adults goals to be attained, and in this case, there would be lower hatchery production costs. Hatchery facilities probably would not be used for other commercial or educational activities than for the purposes for which they were built, so the effects from hatchery operation changes would be assumed to not have a mitigating substitute. Reduced DCCO predation would increase economic contributions from fisheries, but be lessened due to the reduced hatchery operations economic effects.

Avian predation sourced to DCCO has been estimated in recent years to be as high as 20 million of the outmigrating smolt biomass. Status quo conditions assumes approximately half of the biomass is hatchery origin, but three-fourths of returning adults comprise the harvests. DCCO predation would represent a $21 million investment assuming $1.50 per smolt release cost, all DCCO predation was curtailed, 30 percent passage mortality, no compensatory predation, and no predation rate differentiation in fish origin.

The status quo conditions economic contributions from in-river fishery sectors (including commercial non-Indian and tribal, and recreational) is shown in Figure 1. The Bonneville Dam separates the commercial non-Indian fishery and commercial tribal fishery harvest areas. (Tribal fisheries are allowed to fish below Bonneville Dam and in the Willamette River if necessary to attain seasonal fish allocations.) The commercial non-Indian fishery is about 15 percent of the estimated $49.1 million total personal income generated by the in-river fisheries. Most of landings are made to lower River located processors. The commercial tribal fishery is 16 percent of in-river fisheries economic contributions. Most of the landings are purchased by processors based in northern Washington. These processors are also active in purchasing Puget Sound commercial tribal harvests.

The freshwater sport fishery (includes the popular fall season Buoy 10 fishery as well as all other mainstem and tributary salmon and steelhead fisheries) trip spending economic contributions are 68 percent of in-river fisheries total economic contributions. (Angler capital expenditures are not included in this estimate because the economic analysis is to calculate economic effects and it is assumed capital items would have been purchased with or without management plan actions.) Lastly there is a minor amount of economic contribution (estimated to be two percent) that comes from the business use of marketable returns to hatcheries. The disposition of the returns can make their way into actual or offsetting financial transactions, including providing reimbursements for hatchery system operation costs. Some disposition of quality fish are donations to local food banks.

There are essentially two basic management plan alternatives being considered, although the means to accomplish the basic alternatives generate additional alternative derivatives. Alternative I is a reduction of 56 percent of the existing colony on East Island to bring the DCCO population down to estuary to a base period level (no more than 5,380 to 5,939 nesting pairs). Alternative II is a reduction of 100 percent of the East Island DCCO population.

The DFV and REI measurements for these alternatives by species and by the three industry sectors are shown in Table 2 and 3. The total DFV effects calculation for the participants is positive $1.5 million for Alternative I and positive $2.7 million for Alternative II. The total REI effects in Columbia River Basin economies from inland fisheries are positive $1.5 million and positive $2.7 million for the two alternatives respectively. The REI percentage change from in-river fisheries is about 3.1 percent greater for Alternative 1 and about 5.5 percent greater for Alternative II. The economic contributions are in economies wherever the returning hatchery and wild origin fish in-river harvesting and processing expenditures are made.

The Astoria (Clatsop County, Oregon) and Ilwaco (Pacific County, Washington) area located at the Columbia River ocean entrance has the largest commercial fishing industry presence of all regional economies adjacent to the River. The fishing industry is not particularly vulnerable to in-river fisheries as the total (ocean harvest area included) commercial salmon fishery is about five percent (measured by harvest revenue) of all fisheries deliveries. The share of those deliveries from in-river commercial non-Indian and tribal fisheries is about 83 percent. While all fisheries harvesting and processing activity is important, a five percent upturn sourced to in-river fisheries due to DCCO management is not a significant increase to the area's fishing industry.

A regional commercial fishing industry perspective is revealing, however dissection of vulnerability for in-river fisheries changes masks participant economic and social impacts. The Astoria area is home to many non-Indian sector permittees whose in-river fishery income is critical to their business. Many of these participants also will travel to Alaska between Columbia River fishing seasons to supplement their local harvesting incomes. An increase in catch in any of their fisheries' participation would be important to the overall viability of their business. Columbia River in-river fisheries present an even higher business risk to commercial tribal fisherman. As a group, they have less resiliency to downturns and enjoy higher proportional benefits from Columbia River harvest changes. Even small increases in harvest revenue due to DCCO management would be important to tribal fisherman household income.

Social implications qualitative discussions provide an interpretation for how changing fishery related economic effects may disproportionately affect socio-economic groups using federal environmental justice criteria. The interpretations are based on a methodological approach to answer the contentious question for fair distribution of environmental burdens and benefits. It is not an unexpected finding that American Indian ethnicity in certain Columbia River Basin geographic areas is a socio-economic group particularly vulnerable to fishery related changes. Given the group's thousands of years of life dependency on Columbia River fish resources, an analysis of fishery changes may more appropriately be analyzed from pre-hatchery system and pre-harvest regime allocation schemes rather than relative to baseline conditions. This finding is particularly apropos to the current DCCO predation reduction considerations because the DCCO consumption problem is post-European settlement. The problem is additive to the drastic alteration in wild origin salmon and steelhead populations caused by the hatchery system, river flows, salmonid habitats, etc. Relegating the social analysis to only discussions of the alternatives' economic analysis marginal changes does not show appreciation for the tribal fisheries as they historically existed.

Discerning changes in regional economic activity due to incremental changes from in-river fisheries does not address a larger policy consideration related to DCCO management. Maintaining and improving Columbia River area in-river fisheries has basis in the conservation of the wild production component. There is ominous government intervention power that follows findings that wild stocks are depleted. The federal Endangered Species Act (ESA) allows for sweeping powers to prevent further takings of listed species that can shut down fisheries. A task not undertaken in the economic analysis would be determining the magnitude of regional economic activity from in-river fisheries at risk from not having healthy wild stocks due wholly or in part from DCCO predation. Moreover, the foregone fisheries benefits would be a small component of total economic activity at risk due to effects from other curtailed land and water uses that would be imposed by the depleted fish population's recovery plans.

Table 1

Economic Analysis Model Baseline Conditions, Exogenous Variables, and Management Plan Alternatives' Specifications

Baseline Conditions

1) Annual average 2000's broodstock survival to analyzed fisheries
2) Recent years' ocean and river harvest exploitation rates
3) Annual average 2008-2012 hatchery production
4) Estimated wild fish production based on hatchery production ratio estimators
5) Constant DCCO predation probabilities from a recent five year annual average dataset

Exogenous Variables

Inriver Transport	50.0%
Passage Mortality (pre-avian predation)	
Transported	0.0%
Inriver Migrants	30.0%
Other Mortality (post-avian predation)	0.0%
Compensatory predation	0.0%

	Status Quo	Alternative I	Alternative II
Alternatives' Specifications			
Predation reduction	0.0%	56.0%	100.0%

Table 2
Economic Effects From DCCO Predation Reduction to Columbia River
In-river Fisheries by Sector and Species for Participant Direct Financial Value

		Effects			
	Status Quo	Alternative I		Alternative II	
Fisheries	Amount (000's)	Change (000's)	% Differ.	Change (000's)	% Differ.
Freshwater sport	32,544	1,310	4.0%	2,340	7.2%
Coho	3,663	66	1.8%	117	3.2%
Chinook					
Spring/summer	4,597	100	2.2%	178	3.9%
Fall	7,118	128	1.8%	228	3.2%
Steelhead	17,120	1,017	5.9%	1,815	10.6%
Sockeye	47	1	2.5%	2	4.4%
Non-Indian commercial	4,259	83	2.0%	149	3.5%
Coho	761	14	1.8%	24	3.2%
Chinook					
Spring/summer	1,842	40	2.2%	71	3.9%
Fall	1,655	30	1.8%	53	3.2%
Steelhead	0	0		0	
Sockeye	1	0	2.5%	0	4.4%
Tribal commercial	4,149	89	2.2%	160	3.8%
Coho	104	2	1.8%	3	3.2%
Chinook					
Spring/summer	2,242	49	2.2%	87	3.9%
Fall	1,617	29	1.8%	52	3.2%
Steelhead	157	9	5.9%	17	10.6%
Sockeye	29	1	2.5%	1	4.4%
Total	40,951	1,483	3.6%	2,648	6.5%
Coho	4,528	81	1.8%	145	3.2%
Chinook					
Spring/summer	8,681	188	2.2%	336	3.9%
Fall	10,390	186	1.8%	332	3.2%
Steelhead	17,277	1,026	5.9%	1,832	10.6%
Sockeye	76	2	2.5%	3	4.4%

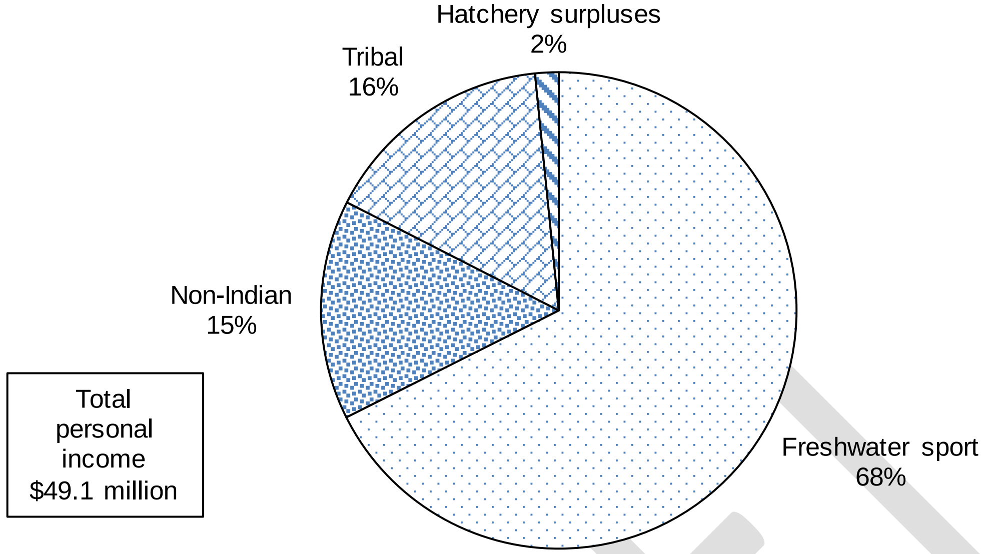
Notes:
1. Direct financial value (DFV) is commercial gillnet and tribal fisheries participant harvest revenue plus recreational angler trip expenditures.
2. DFV is in thousands of Year 2012 dollars adjusted using the GDP implicit price deflator developed by the U.S. Bureau of Economic Analysis.
3. Effects are model outcomes for alternatives' changed conditions minus status quo conditions.

Table 3
Economic Effects From DCCO Predation Reduction to Columbia River
In-river Fisheries by Sector and Species for Regional Economic Impacts

		Effects			
	Status Quo	Alternative I		Alternative II	
Fisheries	Amount (000's)	Change (000's)	% Differ.	Change (000's)	% Differ.
Freshwater sport	33,200	1,171	3.5%	2,091	6.3%
Coho	2,734	49	1.8%	87	3.2%
Chinook					
Spring/summer	12,336	267	2.2%	477	3.9%
Fall	5,314	95	1.8%	170	3.2%
Steelhead	12,781	759	5.9%	1,355	10.6%
Sockeye	35	1	2.5%	2	4.4%
Non-Indian commercial	7,350	143	1.9%	255	3.5%
Coho	1,356	24	1.8%	43	3.2%
Chinook					
Spring/summer	2,993	65	2.2%	116	3.9%
Fall	2,998	54	1.8%	96	3.2%
Steelhead	0	0		0	
Sockeye	3	0	2.5%	0	4.4%
Tribal commercial	7,806	189	2.4%	337	4.3%
Coho	197	4	1.8%	6	3.2%
Chinook					
Spring/summer	3,721	81	2.2%	144	3.9%
Fall	2,922	52	1.8%	93	3.2%
Steelhead	823	49	5.9%	87	10.6%
Sockeye	143	4	2.5%	6	4.4%
Total	48,355	1,503	3.1%	2,683	5.5%
Coho	4,288	77	1.8%	137	3.2%
Chinook					
Spring/summer	19,049	412	2.2%	736	3.9%
Fall	11,233	201	1.8%	359	3.2%
Steelhead	13,604	808	5.9%	1,443	10.6%
Sockeye	181	4	2.5%	8	4.4%

Notes: 1. Regional economic impacts (REI) are expressed as personal income. REI is in thousands of Year 2012 dollars adjusted using the GDP implicit price deflator developed by the U.S. Bureau of Economic Analysis.
2. Effects are model outcomes for alternatives' changed conditions minus status quo conditions.

Figure 1
Columbia River In-river Fisheries Regional Economic Impacts for Status Quo Conditions

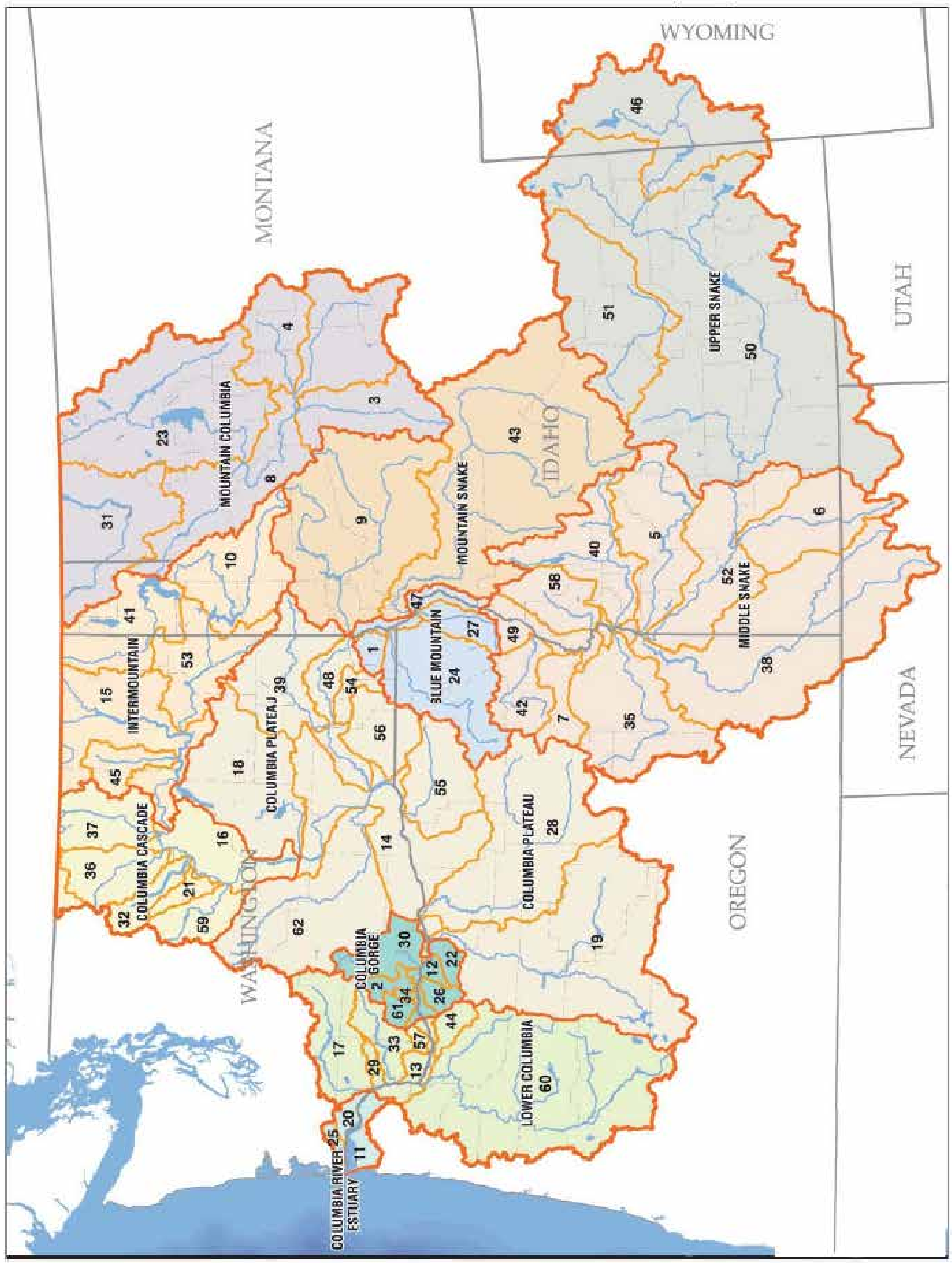


Notes: 1. Regional economic impacts (REI) measurement is total personal income in millions of 2012 dollars.

2. REI includes minor economic contributions from business use of marketable hatchery returns. REI does not include economic contributions from hatchery operations

Figure 2

Boundaries for Columbia River Basin Provinces and Subbasins Superimposed on Counties



Source: Northwest Power Planning Council (2000). Map by Northwest Habitat Institute, Corvallis, Oregon.

Columbia River Hatchery and Wild Origin Production Adult Survival Change Due to DCCO Management Plan Actions (Model Inputs and Outputs)

Filter: Status Quo

Outmigrants	CRFPC Estimate
SAS's	2000's Brood Year
Contribution to Fisheries	AHA Model
Inriver Transport	50.0%
Passage Mortality (pre-predation)	
Transported	0.0%
Inriver Migrants	30.0%
Other Mortality (post-predation)	0.0%

Notes:
1. Outmigrant estimates are hatchery releases.
2. SAS's account for downriver passage and ocean mortalities. The ratio is a survival index for adults showing up in harvests, returns to hatcheries, and spawning beds.
3. Inriver transport survival factor accounts for the saved juveniles not experiencing the passage mortality causes included in the overall SAS.
4. Other mortality accounts for non-compensatory related effects on outmigrants.

Stocks	Snake R.	U. Columbia	M. Columbia	L. Columbia	Willamette	Total
Coho						
Outmigrants	928,159	2,538,643	5,182,116	12,137,734	469,442	21,256,093
Outmigrants Less Passage Mortality	788,935	1,777,050	3,627,481	8,496,414	328,609	15,018,489
SAS's	1.61%	1.61%	1.61%	1.61%	1.61%	
Unaltered Population Predation Rate	3.1%	3.1%	3.1%	3.1%	3.1%	
Unaltered Predation	24,457	55,089	112,452	263,389	10,187	465,573
Inriver Survival	764,478	1,721,961	3,515,029	8,233,025	318,423	14,552,916
Other Mortality	-	-	-	-	-	-
Adjusted Outmigrants	764,478	1,721,961	3,515,029	8,233,025	318,423	14,552,916
Adult Returns (total)	12,308	27,724	56,592	132,552	5,127	234,302
Spring/Summer Chinook						
Outmigrants	20,612,109	12,685,019	7,337,876	6,833,569	10,317,392	57,785,963
Outmigrants Less Passage Mortality	17,520,292	8,879,513	5,136,513	4,783,498	7,222,174	43,541,991
SAS's	0.24%	0.24%	0.24%	0.24%	0.24%	
Unaltered Population Predation Rate	4.7%	3.5%	3.5%	3.5%	2.0%	
Unaltered Predation	826,958	307,231	177,723	165,509	142,999	1,620,420
Inriver Survival	16,693,335	8,572,282	4,958,790	4,617,989	7,079,175	41,921,570
Other Mortality	-	-	-	-	-	-
Adjusted Outmigrants	16,693,335	8,572,282	4,958,790	4,617,989	7,079,175	41,921,570
Adult Returns (total)	39,756	20,415	11,809	10,998	16,859	99,837
Fall Chinook						
Outmigrants	14,375,231	28,825,662	54,330,568	68,472,952	-	166,004,414
Outmigrants Less Passage Mortality	12,218,946	20,177,964	38,031,398	47,931,067	-	118,359,374
SAS's	0.33%	0.33%	0.33%	0.33%	0.33%	
Share subyearlings	75.0%	75.0%	75.0%	75.0%	75.0%	
Unaltered Population Predation Rate	3.1%	3.1%	3.1%	3.1%	3.1%	
Unaltered Predation	378,787	625,517	1,178,973	1,485,863	-	3,669,141
Inriver Survival	11,840,159	19,552,447	36,852,425	46,445,204	-	114,690,234
Other Mortality	-	-	-	-	-	-
Adjusted Outmigrants	11,840,159	19,552,447	36,852,425	46,445,204	-	114,690,234
Adult Returns (total)	39,483	65,200	122,889	154,878	-	382,450
Summer/Winter Steelhead						
Outmigrants	14,469,969	2,093,827	897,446	4,457,535	1,734,728	23,653,505
Outmigrants Less Passage Mortality	12,299,474	1,465,679	628,212	3,120,275	1,214,310	18,727,949
SAS's	0.55%	0.55%	0.55%	0.55%	0.55%	
Unaltered Population Predation Rate	9.8%	7.6%	9.6%	9.6%	9.6%	
Unaltered Predation	1,205,348	111,685	60,560	300,794	117,059	1,795,447
Inriver Survival	11,094,125	1,353,994	567,653	2,819,480	1,097,250	16,932,502
Other Mortality	-	-	-	-	-	-
Adjusted Outmigrants	11,094,125	1,353,994	567,653	2,819,480	1,097,250	16,932,502
Adult Returns (total)	60,889	7,431	3,116	15,474	6,022	92,933
Sockeye						
Outmigrants	588,974	3,097,283	-	-	-	3,686,257
Outmigrants Less Passage Mortality	500,628	2,168,098	-	-	-	2,668,726
SAS's	0.24%	0.24%	0.24%	0.24%	0.24%	
Unaltered Population Predation Rate	4.2%	4.2%	4.2%	4.2%	4.2%	
Unaltered Predation	21,026	91,060	-	-	-	112,086
Inriver Survival	479,601	2,077,038	-	-	-	2,556,639
Other Mortality	-	-	-	-	-	-
Adjusted Outmigrants	479,601	2,077,038	-	-	-	2,556,639
Adult Returns (total)	1,142	4,947	-	-	-	6,089
Total						
Outmigrants	50,974,442	49,240,433	67,748,006	91,901,790	12,521,562	272,386,233
Unaltered Predation	2,456,577	1,190,581	1,529,708	2,215,555	270,245	7,662,667
Adult Returns (total)	153,578	125,717	194,406	313,902	28,008	815,610

Filter: **Alternative I**						
Outmigrants	CRFPC Estimate					
SAS's	2000's Brood Year					
Contribution to Fisheries	AHA Model					
Inriver Transport	50.0%					
Passage Mortality (pre-predation)						
Transported	0.0%					
Inriver Migrants	30.0%					
Other Mortality (post-predation)	0.0%					
Predation Reduction	56.0%					
Compensatory Mortality	0.0%					
Notes:						
1. Predation reduction estimates from draft DCCO Management Plan EIS.						
2. Compensatory predation mortality is the share of fish consumed by other predators that would have died from other factors subsequent to the cormorant predation event.						
Stocks	Snake R.	U. Columbia	M. Columbia	L. Columbia	Willamette	Total
Coho						
Outmigrants	928,159	2,538,643	5,182,116	12,137,734	469,442	21,256,093
Outmigrants Less Passage Mortality	788,935	1,777,050	3,627,481	8,496,414	328,609	15,018,489
SAS's	1.61%	1.61%	1.61%	1.61%	1.61%	
Unaltered Population Predation Rate	3.1%	3.1%	3.1%	3.1%	3.1%	
Unaltered Predation	24,457	55,089	112,452	263,389	10,187	465,573
Predation Reduction (including compensatory mortality)	13,696	30,850	62,973	147,498	5,705	260,721
Adjusted Reduction (predation reduction less other mortality)	13,696	30,850	62,973	147,498	5,705	260,721
Adult Returns	221	497	1,014	2,375	92	4,198
Spring/Summer Chinook						
Outmigrants	20,612,109	12,685,019	7,337,876	6,833,569	10,317,392	57,785,963
Outmigrants Less Passage Mortality	17,520,292	8,879,513	5,136,513	4,783,498	7,222,174	43,541,991
SAS's	0.24%	0.24%	0.24%	0.24%	0.24%	
Unaltered Population Predation Rate	4.7%	3.5%	3.5%	3.5%	2.0%	
Unaltered Predation	826,958	307,231	177,723	165,509	142,999	1,620,420
Predation Reduction (including compensatory mortality)	463,096	172,049	99,525	92,685	80,079	907,435
Adjusted Reduction (predation reduction less other mortality)	463,096	172,049	99,525	92,685	80,079	907,435
Adult Returns	1,103	410	237	221	191	2,161
Fall Chinook						
Outmigrants	14,375,231	28,825,662	54,330,568	68,472,952	-	166,004,414
Outmigrants Less Passage Mortality	12,218,946	20,177,964	38,031,398	47,931,067	-	118,359,374
SAS's	0.33%	0.33%	0.33%	0.33%	0.33%	
Share subyearlings	75.0%	75.0%	75.0%	75.0%	75.0%	
Unaltered Population Predation Rate	3.1%	3.1%	3.1%	3.1%	3.1%	
Unaltered Predation	378,787	625,517	1,178,973	1,485,863	-	3,669,141
Predation Reduction (including compensatory mortality)	212,121	350,289	660,225	832,083	-	2,054,719
Adjusted Reduction (predation reduction less other mortality)	212,121	350,289	660,225	832,083	-	2,054,719
Adult Returns	707	1,168	2,202	2,775	-	6,852
Summer/Winter Steelhead						
Outmigrants	14,469,969	2,093,827	897,446	4,457,535	1,734,728	23,653,505
Outmigrants Less Passage Mortality	12,299,474	1,465,679	628,212	3,120,275	1,214,310	18,727,949
SAS's	0.55%	0.55%	0.55%	0.55%	0.55%	
Unaltered Population Predation Rate	9.8%	7.6%	9.6%	9.6%	9.6%	
Unaltered Predation	1,205,348	111,685	60,560	300,794	117,059	1,795,447
Predation Reduction (including compensatory mortality)	674,995	62,543	33,913	168,445	65,553	1,005,450
Adjusted Reduction (predation reduction less other mortality)	674,995	62,543	33,913	168,445	65,553	1,005,450
Adult Returns	3,705	343	186	924	360	5,518
Sockeye						
Outmigrants	588,974	3,097,283	-	-	-	3,686,257
Outmigrants Less Passage Mortality	500,628	2,168,098	-	-	-	2,668,726
SAS's	0.24%	0.24%	0.24%	0.24%	0.24%	
Unaltered Population Predation Rate	4.2%	4.2%	4.2%	4.2%	4.2%	
Unaltered Predation	21,026	91,060	-	-	-	112,086
Predation Reduction (including compensatory mortality)	11,775	50,994	-	-	-	62,768
Adjusted Reduction (predation reduction less other mortality)	11,775	50,994	-	-	-	62,768
Adult Returns	28	121	-	-	-	149
Total						
Outmigrants	50,974,442	49,240,433	67,748,006	91,901,790	12,521,562	272,386,233
Adult Survival Due to Change	5,763	2,539	3,639	6,295	642	18,878

Filter: Alternative II						
Outmigrants	CRFPC Estimate					
SAS's	2000's Brood Year					
Contribution to Fisheries	AHA Model					
Inriver Transport	50.0%					
Passage Mortality (pre-predation)						
Transported	0.0%					
Inriver Migrants	30.0%					
Other Mortality (post-predation)	0.0%					
Predation Reduction	100.0%					
Compensatory Mortality	0.0%					
Notes:						
1. Predation reduction estimates from draft DCCO Management Plan EIS.						
2. Compensatory predation mortality is the share of fish consumed by other predators that would have died from other factors subsequent to the cormorant predation event.						
Stocks	Snake R.	U. Columbia	M. Columbia	L. Columbia	Willamette	Total
Coho						
Outmigrants	928,159	2,538,643	5,182,116	12,137,734	469,442	21,256,093
Outmigrants Less Passage Mortality	788,935	1,777,050	3,627,481	8,496,414	328,609	15,018,489
SAS's	1.61%	1.61%	1.61%	1.61%	1.61%	
Unaltered Population Predation Rate	3.1%	3.1%	3.1%	3.1%	3.1%	
Unaltered Predation	24,457	55,089	112,452	263,389	10,187	465,573
Predation Reduction (including compensatory mortality)	24,457	55,089	112,452	263,389	10,187	465,573
Adjusted Reduction (predation reduction less other mortality)	24,457	55,089	112,452	263,389	10,187	465,573
Adult Returns	394	887	1,810	4,241	164	7,496
Spring/Summer Chinook						
Outmigrants	20,612,109	12,685,019	7,337,876	6,833,569	10,317,392	57,785,963
Outmigrants Less Passage Mortality	17,520,292	8,879,513	5,136,513	4,783,498	7,222,174	43,541,991
SAS's	0.24%	0.24%	0.24%	0.24%	0.24%	
Unaltered Population Predation Rate	4.7%	3.5%	3.5%	3.5%	2.0%	
Unaltered Predation	826,958	307,231	177,723	165,509	142,999	1,620,420
Predation Reduction (including compensatory mortality)	826,958	307,231	177,723	165,509	142,999	1,620,420
Adjusted Reduction (predation reduction less other mortality)	826,958	307,231	177,723	165,509	142,999	1,620,420
Adult Returns	1,969	732	423	394	341	3,859
Fall Chinook						
Outmigrants	14,375,231	28,825,662	54,330,568	68,472,952	-	166,004,414
Outmigrants Less Passage Mortality	12,218,946	20,177,964	38,031,398	47,931,067	-	118,359,374
SAS's	0.33%	0.33%	0.33%	0.33%	0.33%	
Share subyearlings	75.0%	75.0%	75.0%	75.0%	75.0%	
Unaltered Population Predation Rate	3.1%	3.1%	3.1%	3.1%	3.1%	
Unaltered Predation	378,787	625,517	1,178,973	1,485,863	-	3,669,141
Predation Reduction (including compensatory mortality)	378,787	625,517	1,178,973	1,485,863	-	3,669,141
Adjusted Reduction (predation reduction less other mortality)	378,787	625,517	1,178,973	1,485,863	-	3,669,141
Adult Returns	1,263	2,086	3,931	4,955	-	12,235
Summer/Winter Steelhead						
Outmigrants	14,469,969	2,093,827	897,446	4,457,535	1,734,728	23,653,505
Outmigrants Less Passage Mortality	12,299,474	1,465,679	628,212	3,120,275	1,214,310	18,727,949
SAS's	0.55%	0.55%	0.55%	0.55%	0.55%	
Unaltered Population Predation Rate	9.8%	7.6%	9.6%	9.6%	9.6%	
Unaltered Predation	1,205,348	111,685	60,560	300,794	117,059	1,795,447
Predation Reduction (including compensatory mortality)	1,205,348	111,685	60,560	300,794	117,059	1,795,447
Adjusted Reduction (predation reduction less other mortality)	1,205,348	111,685	60,560	300,794	117,059	1,795,447
Adult Returns	6,615	613	332	1,651	642	9,854
Sockeye						
Outmigrants	588,974	3,097,283	-	-	-	3,686,257
Outmigrants Less Passage Mortality	500,628	2,168,098	-	-	-	2,668,726
SAS's	0.24%	0.24%	0.24%	0.24%	0.24%	
Unaltered Population Predation Rate	4.2%	4.2%	4.2%	4.2%	4.2%	
Unaltered Predation	21,026	91,060	-	-	-	112,086
Predation Reduction (including compensatory mortality)	21,026	91,060	-	-	-	112,086
Adjusted Reduction (predation reduction less other mortality)	21,026	91,060	-	-	-	112,086
Adult Returns	50	217	-	-	-	267
Total						
Outmigrants	50,974,442	49,240,433	67,748,006	91,901,790	12,521,562	272,386,233
Adult Survival Due to Change	10,292	4,534	6,498	11,240	1,147	33,711

Agenda Item D.2.a
Supplemental Attachment 3
June 2014

Double-crested Cormorant Management Plan/EIS

Joyce E. Casey

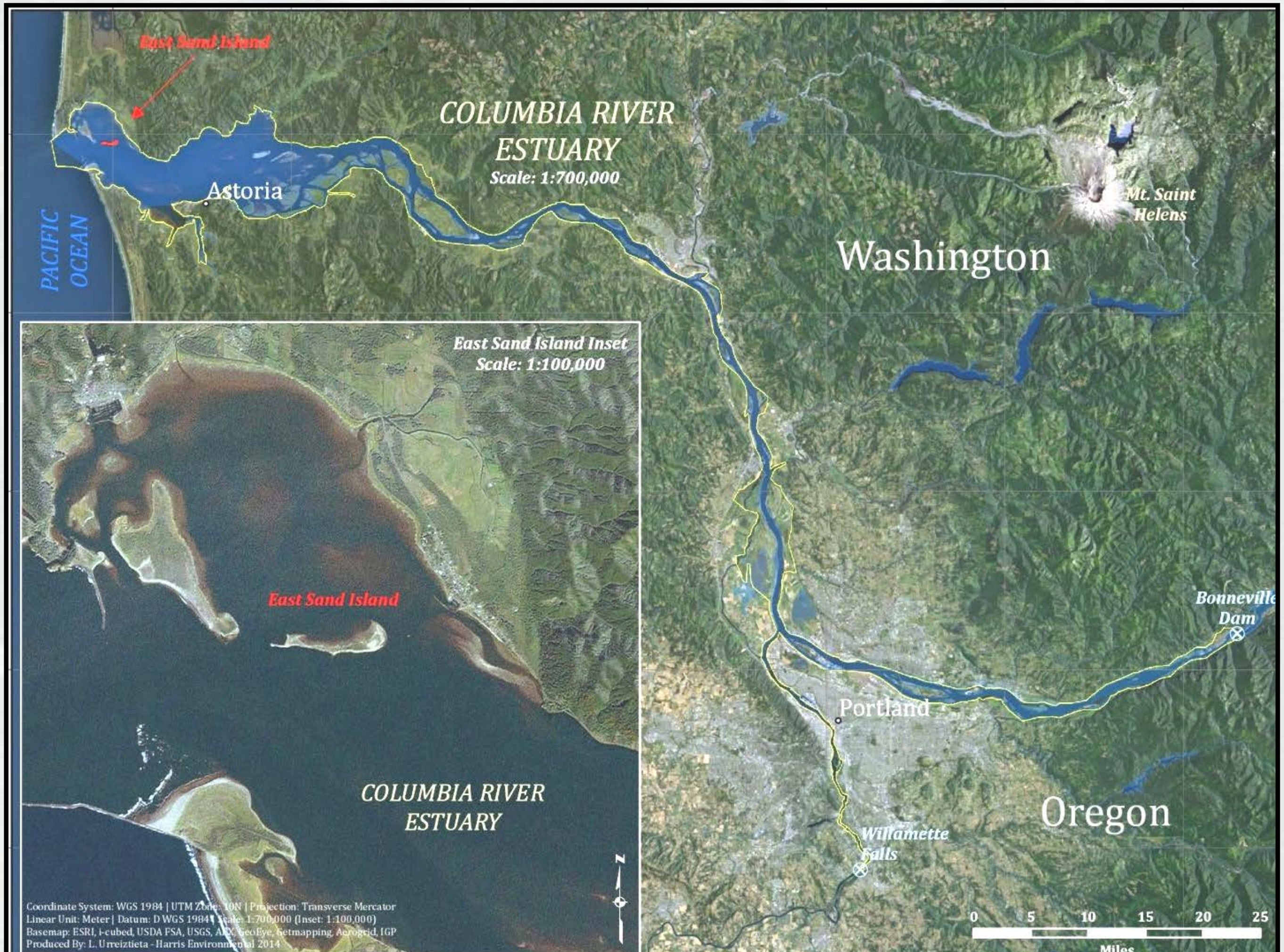
Chief, Environmental Resources Branch

Portland District

June 12, 2014

US Army Corps of Engineers
BUILDING STRONG®

Columbia River Estuary



East Sand Island

- Managed by the Corps of Engineers
- Located at the mouth of the Columbia and is 60 acres
- During nesting season upwards of 60,000 piscivorous individuals present
- Nesting season overlaps with the migration of juvenile salmonids

Objective and considerations

- Objective: Reduce rate of cormorant predation on ESA-listed juvenile salmonids in the Columbia River estuary
- What needs to be considered in alternative development
  - Reduce predation on ESA-listed juvenile salmonids (RPA 46)
  - Evaluate effects on protected resources
- Alternatives considered must meet the objectives

Federal Columbia River Power System Biological Opinion Actions: An All-H Approach

- **Predation**
  - Avian, sea lions – Corps
  - Pikeminnow – BPA
- **Habitat**
  - Tributary – BPA, Reclamation
  - Estuary – Corps, BPA
- **Hatchery Reform** – BPA, Corps, Reclamation
- **Harvest** – BPA, NOAA Fisheries
  - **Research, Monitoring and Evaluation** – BPA, Corps, Reclamation, NOAA Fisheries

- **Hydro – Corps of Engineers**
  - **Flow augmentation**
  - **Configuration actions**
  - **Dam operations (spill, transport)**

Revised RPA 46

- Reduce cormorant predation in the estuary to base period levels (between 5,380 and 5,939 nesting pairs)
- Colony reduction would result in a continued steelhead consumption rate equivalent to base period
- Colony reduction is estimated to increase steelhead survival by 3.6 percent

EIS Alternatives

- **Alternative A**: No Action
- **Alternative B**: Non-Lethal Focus
  - Phase 1 (years 1-4) – Primarily non-lethal actions to reduce colony size, limited egg take
- **Alternative C**: Lethal Focus
  - Phase 1 (years 1-4) – Primarily lethal actions to reduce colony size
- **Alternative D**: Lethal Focus and Exclusion of Nesting on East Sand Island
  - Phase 1 (years 1-4) – Primarily lethal actions to reduce colony size

Phase 2 (all alternatives): (years 5-10) – Maintain colony size

Decision making considerations

- Greatest certainty of meeting project goals
- Feasibility in implementation
- Impacts to other protected species
- Schedule
- Cost
- Corps' actions must remain within our authorities

Preferred alternative: Alternative C

- Best meets purpose and need
- Most technically feasible
- Minimizes long-term environmental effects of dispersal
- Economic cost is lower

Non-lethal methods considered

- Habitat reduction/modification: actions such as planting vegetation, placing artificial barriers and constructing ponds
- Hazing: flushing individuals with human presence
- Visual deterrents: items such as eagle kites and predator effigies
- Noise deterrents: tools such as propane cannons and pyrotechnics

Lethal methods considered

- Take of individuals: shooting on land and over water, or using other methods consistent with American Veterinary Medical Association guidelines
- Take of eggs: oiling eggs by spraying food-grade vegetable oil, active nest destruction, or collection of eggs

EIS Schedule

- Draft EIS released to public and notice sent for posting June 12, 2014
- Draft EIS notice posted in Federal Register June 19, 2014; public comment period begins
  - The 45-day public comment period ends Aug. 4, 2014
- Final EIS will be posted in Federal Register September 25, 2014
- Record of Decision will be signed December 29, 2014
- Implementation actions March 2015

Submitting public comments

Comments should include the public notice number (CENWP-PM-E-14-06), title and date. Written comments may be sent electronically to **cormorant-eis@usace.army.mil** or by traditional mail to:

Sondra Ruckwardt
U.S. Army Corps of Engineers, Portland District,
Attn: CENWP-PM-E/Double-crested Cormorant draft EIS
P.O. Box 2946
Portland, Oregon 97208-2946

To view the draft EIS or learn more about double-crested cormorants visit the Corps' website at www.nwp.usace.army.mil *(click on Current Projects and then Cormorant EIS)*

Scheduled informational meetings

Portland
Thursday, July 10, 2014   2:30-5:30 p.m.
Matt Dishman Community Center, 77 N.E. Knott St.

Astoria
Thursday, July 24, 2014   3-6 p.m.
Best Western Lincoln Inn, 555 Hamburg Ave.

Webinars
July 15 9:30-11 a.m.
July 21 1:30-3 p.m.

For information on how to join the webinars please visit
www.nwp.usace.army.mil/missions/currentprojects/cormorant.eis

Agenda Item D.2.c
Supplemental SAS Report
June 2014

SALMON ADVISORY SUBPANEL REPORT ON THE COLUMBIA RIVER CORMORANT MANAGEMENT PLAN

The Salmon Advisory Subpanel (SAS) met via webinar with the Salmon Technical Team and members of the Lower Columbia River Natural Coho Workgroup (LRC Workgroup) on Thursday, June 12, 2014. The SAS received a presentation from Ms. Joyce Casey, the Environmental Chief of the Portland District of the U.S. Army Corps of Engineers (USACE). The SAS had a good discussion of the issue despite the later than anticipated release of the Draft Environmental Impact Statement the morning of the webinar.

The SAS supports efforts to reduce predation on salmonids by double-crested cormorants and recommends that the Council send a letter to the USACE in favor of Alternative C: Lethal Focus. The SAS believes that this alternative is the most effective way to achieve the goals of the current Biological Opinion on Columbia River salmonids listed under the Endangered Species Act. The SAS does not support non-lethal alternatives because birds often become acclimated to hazing efforts and, when effective, hazing simply displaces birds, creating predation problems in other parts of the Columbia River Basin or in other river systems.

The SAS would like to stress that achieving the target level of 5,380 to 5,939 nesting pairs through Alternative C and lethal methods is a good first step towards addressing the avian predation problem and should be considered a minimal effort. At this level of nesting, cormorants will continue to present a formidable challenge to salmon survival in the estuary, particularly when combined with avian predation from other bird species.

PFMC
06/19/14